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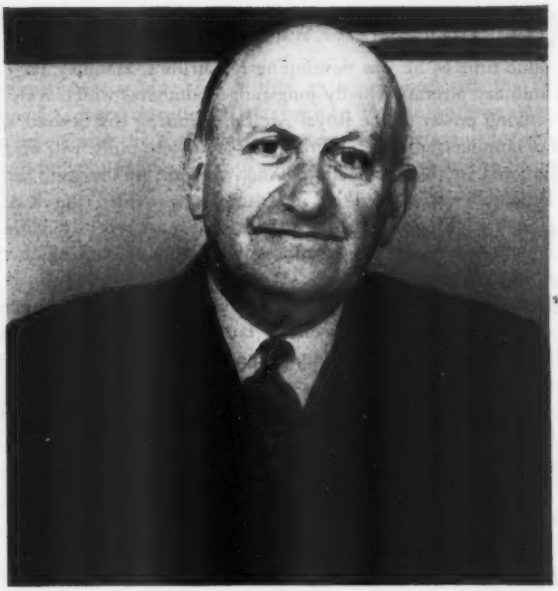
AWARD OF THE ALBERT MEDAL FOR 1960



[*Keystone Press*

With the approval of His Royal Highness the President, the Albert Medal for 1960 has been awarded to Sir Frederick Handley Page, C.B.E., 'for his leadership in the design and manufacture of aircraft'.

As early as 1906, Frederick Handley Page, then aged 21 and by profession an electrical engineer, was one of a small band of pioneers interested in flying. Two years later he founded the first British works to be constructed exclusively for the manufacture of aircraft, and he has remained in control of this firm ever since. By 1914 he had already produced more than one notable powered aeroplane,

but it was in response to the needs of war that he made his outstanding early advance in aeronautical engineering, with the production of the first successful big bomber, the twin-engined H.P. 0/100 (1915), and of its successors, the 0/400 and V/1500 (the 'Super Handley'). From the H.P 0/100 stems the whole history of bomber aircraft.

It may be said with equal justice that in the years following the First World War Handley Page helped to lay the foundations of serious British civil aviation. He was the pioneer of commercial air transport to Europe, and designed a succession of airliners, culminating in the famous H.P. 42 Hannibal/Hercules class. These first flew in 1930 on the great trunk routes of the Continent, to Africa and the Far East, and remained in service—without an accident—for over eight years. In 1928 the Air Ministry adopted Handley Page's device of the slotted wing—perhaps his most important basic contribution to the progress of aviation. Since then H.P. slots have been incorporated in aircraft built all over the world.

At the same time as he was developing his airlines, Handley Page continued to design military aircraft, chiefly long-range bombers, which were to furnish the main striking power of the Royal Air Force during the Second World War. The Halifax bombers, of which more than 6,000 were built, will be particularly well remembered in this connection. Since the end of the war, Sir Frederick Handley Page, who was knighted in 1942, has provided the R.A.F. with a standard 4-engined Transport, the Hastings, and most recently, with the Victor bomber, which has made many impressive flights, including a 188-minute crossing of the Atlantic.

Throughout the post-war years Sir Frederick has devoted much effort to research—chiefly on the development of laminar flow techniques—and to the promotion of technical education. He has been Chairman of Council of the City and Guilds of London Institute since 1950, and is Chairman of the Board of Governors of the College of Aeronautics. He is also a Governor and Fellow of the Imperial College of Science and Technology. His connection with the Royal Aeronautical Society is itself significant of the continuity of his career. President in 1945–47, he became a member fifty-two years ago—two years before it became a fully constituted scientific organization.

FINAL MEETINGS OF THE SESSION

WEDNESDAY, 25TH MAY, at 2.30 p.m. '*The Problems and Prospects of Air Transport*', by Peter G. Masefield, M.A., F.R.Ae.S., President, Royal Aeronautical Society. Sir George Edwards, C.B.E., Managing Director of Vickers-Armstrong (Aircraft) Ltd., and a Vice-President of the Society, in the Chair.

THURSDAY, 26TH MAY, at 5.15 p.m. COMMONWEALTH SECTION. HENRY MORLEY LECTURE. '*Recent Developments in Fiji*', by Sir Alan Burns, G.C.M.G. The Right Honble. the Earl of Perth, P.C., Minister of State for Colonial Affairs,

in the Chair. (The lecture will be illustrated by lantern slides. Tea will be served in the Library from 4.30 p.m.)

WEDNESDAY, 1ST JUNE, at 2.30 p.m. ALFRED BOSSOM LECTURE. '*The Crisis of Urban England*', by the Honble. Lionel Brett, M.A., F.R.I.B.A. The Right Honble. Lord Bossom, LL.D., F.R.I.B.A., J.P., a Vice-President of the Society, in the Chair.

Fellows are entitled to attend any of the Society's meetings without tickets (except where otherwise stated), and may also bring two guests. When they cannot accompany their guests, Fellows may give them special passes, books of which can be obtained on application to the Secretary. Official representatives of Companies in association with the Society may also attend with one guest.

ANNUAL GENERAL MEETING

The Council hereby gives notice that, in accordance with the Bye-laws, the 206th Annual General Meeting of the Society, for the purpose of receiving the Council's report and the Financial Statements for 1959, and for the election of officers, will be held on Wednesday, 29th June, at 3 p.m. at the Society's House.

(By Order of the Council)

KENNETH WILLIAM LUCKHURST,
Secretary.

PROGRAMME FOR THE 207TH SESSION

The Council will shortly be considering the Programme of Meetings for the forthcoming Session. Fellows are invited to forward suggestions for lectures and papers to the Secretary by 10th June.

CHAIRMAN OF COUNCIL'S VISIT TO BIRMINGHAM

The Chairman of Council, accompanied by Sir Ernest Goodale, Mr. Milner Gray, and Mr. G. C. H. Chubb, with the Secretary and the Deputy Secretary, met 51 Fellows of the Society living in the Midlands at dinner at Birmingham on Monday, 2nd May.

The dinner was arranged with the twofold purpose of bringing local Fellows together and of discussing with them the form which any possible extension of the Society's activities might take in that City. After dinner there was a lively discussion, from which it was clear that those present welcomed the Council's initiative in this matter and were unanimous in agreeing that there was scope for the arrangement of activities in the Midlands. The general consensus of opinion was that perhaps two functions a year might be arranged as a beginning, and several useful suggestions were made as to the form which these might take.

The Council is now giving consideration to the possibility of arranging functions in the Midlands on the lines discussed, and also to the possibility of meeting Fellows in other important centres in the provinces to ascertain their views on the desirability of arranging local activities in those areas.

INDUSTRIAL ART BURSARIES EXHIBITION

The exhibition of winning and commended designs in the 1959 Industrial Art Bursaries Competition, which was opened by Mr. Whitney Straight on 17th May, will remain on view in the Society's exhibition rooms (*which are reached from* 18 *Adam Street*) until 3rd June. The hours of viewing are as follows: Mondays to Fridays, 10 a.m. to 5.30 p.m.; Saturdays, 10 a.m. to 12.30 p.m.

A full account of the opening ceremony on 17th May will be published in the next issue of the *Journal.*

PARTY IN HONOUR OF MR. VINCENT MASSEY

The Chairman and Members of Council gave a sherry party in honour of Mr. Vincent Massey, the former Governor-General of Canada, at the Society's House on Tuesday, 3rd May. It will be remembered that in May of last year Mr. Massey was awarded the Society's Albert Medal 'for his distinguished encouragement of the arts and sciences', and particularly for his work in Canada as Chairman of what has come to be known as the Massey Commission. During this, his first, visit to the Society's House, Mr. Massey inscribed the Society's own copy of the report made by that Commission.

NEW HONORARY CORRESPONDING MEMBER OF THE SOCIETY

The Council has appointed the following to be an Honorary Corresponding Member of the Society:

Manitoba, Canada: J. R. Weir, B.S.A., M.Sc., Ph.D., The University of Manitoba, Winnipeg, Manitoba.

MEETING OF COUNCIL

A meeting of Council was held on Monday, 9th May. Present: Mr. Oswald P. Milne (in the Chair); Mrs. Mary Adams; Mr. R. E. Dangerfield; Sir George Edwards; Mr. Geoffrey de Freitas; Mr. Peter Le Neve Foster; Mr. E. Maxwell Fry; Mr. John Gloag; Sir Ernest Goodale; Dr. Stanley Gooding; Mr. Milner Gray; Dr. R. W. Holland; Mr. Antony Hopkins; Lord Latham; Mr. Edgar Lawley; Mr. F. A. Mercer; Lord Nathan; Mr. Paul Reilly; Mr. A. R. N. Roberts; Sir Philip Southwell; Professor S. Tolansky; Mr. G. E. Tonge; Mr.

Hugh A. Warren and Miss Anna Zinkeisen; with Dr. K. W. Luckhurst (Secretary); Mr. G. E. Mercer (Deputy-Secretary), and Mr. J. S. Skidmore (Assistant Secretary).

ELECTIONS

The following Fellows of the Society were appointed Benjamin Franklin Fellows:

Brownlow, H. B. S., M.A.S.C.E., M.E.I.C., A.M.I.Struct.E.
Chapman, Albert Kinkade, A.M., Ph.D.
Cheney, Sheldon, B.A.
Chute, Miss Marchette Gaylord.
Cisler, Walker Lee, M.E., O.B.E.
Edwards, Miss Nettie Elizabeth.
Gannon, The Reverend Robert Ignatius, M.A., Litt.D., LL.D.
Hann, Victor Adams, B.S.
Harbeson, John Frederick, M.S.
Lescaze, William, M.Arch.
Liebes, Mrs. Dorothy, B.A., LL.D.
Milliken, William Mathewson, A.B.
Penrose, Charles, Jr.
Robinson, Admiral Samuel M., U.S.N.(ret.).
Steinman, David Barnard, B.S., A.M., C.E., Ph.D., Sc.D.
Vaux, George.
Wylie, Alexander Matthew, B.Sc.

The following candidates were duly elected Fellows of the Society (those whose names are marked with an asterisk were elected Benjamin Franklin Fellows):

Atkinson, Miss Bessie, Brockworth, Glos.
Baker, Robin Richard, Ashford, Middx.
Baybut, Harry, Greenford, Middx.
Best, Allan, Burnley, Lancs.
*Bodfish, Morton, Chicago, Illinois, U.S.A.
Bottomley, Charles Matthew, A.T.I., Halifax, Yorks.
Brandwood, The Reverend William, Blackburn, Lancs.
Cannon, Alan George, B.A., A.K.C., London.
*Coursolle, Nazard Matthias, St. Paul, Minnesota, U.S.A.
Dalton, Percival George, A.M.I.N.A., Falmouth, Cornwall.
*Donovan, Harry J., New York, N.Y., U.S.A.
Goodwin, Leslie Albert, Leicester.
Goldberg, Harry, B.Com., Johannesburg, South Africa.
*Holland, G. Kenneth, New York, N.Y., U.S.A.
*Houghton, Arthur Amory, Jr., New York, N.Y., U.S.A.
Howatson, Alexander Cunningham, New York, N.Y., U.S.A.
Jenkins, Roy, Sutton-in-Ashfield, Notts.
Knapman, Frederick Arthur Geoffrey, Hanworth, Middx.
Kooraram, Moonasur, Phoenix, Mauritius.
Massey, The Right Honble. Vincent, C.H., Port Hope, Canada.
McDermott, Joseph Leo, Littlehampton, Sussex.
McGeoghegan, Bernard, Teddington, Middx.
McWilliam, William Kitchener, Belfast, Northern Ireland.

Newall, Mrs. Venetia June, M.A., London.
Ortiz, Ernesto Miranda, M.D., Mexico, D.F.
Petrie-Baker, Raymond, Burgess Hill, Sussex.
Reid, Professor William Stanford, M.A., Th.M., Ph.D., Montreal, P.Q., Canada.
Scott, Peter Francis, B.A., Kendal, Westmorland.
Shone, Sir Robert Minshull, C.B.E., London.
Spence, Basil, O.B.E., T.D., R.A., A.R.S.A., P.R.I.B.A., London.
*Volz, Carl William, Scarsdale, N.Y., U.S.A.
Whyles, Michael George, Rayleigh, Essex.
Willis, John England, Southsea, Hants.

The following Companies were admitted into association with the Society:

Central Electricity Generating Board, London.
Dewhurst and Partner Ltd., Hounslow, Middx.

NEW HONORARY CORRESPONDING MEMBER

Approval was given to the appointment of a new Honorary Corresponding Member of the Society in Manitoba, Canada. (See separate Notice on p. 474.)

ALBERT MEDAL

It was agreed to recommend to H.R.H. the President that the Albert Medal for 1960 be awarded to Sir Frederick Handley Page. (See separate Notice on p. 471.)

BALLOTING LIST

The Balloting List for the new Council was prepared for the Annual General Meeting.

EXAMINATIONS FEES

Approval was given to certain increases payable by candidates taking the Society's examinations, and to corresponding increases in the fees payable to examiners.

COMMONWEALTH FILM AWARD

Approval was given to a proposal that the Society should offer an award for documentary film production in the Commonwealth.

TENTH ANNIVERSARY OF THE FESTIVAL OF BRITAIN

Consideration was given to a proposal that the Society should mark the tenth anniversary of the Festival of Britain by a series of papers to be read at Ordinary Meetings during 1961.

ANY OTHER BUSINESS

A quantity of financial and other business was transacted.

THE ART OF GLASS ENGRAVING

A paper by

HELEN MONRO, M.A.,

of Edinburgh College of Art, read to the Society on Wednesday, 10th February, 1960, with Paul Reilly, Director, Council of Industrial Design, in the Chair

THE CHAIRMAN: It is one of the privileges of Members of the Council of the Royal Society of Arts to be asked to take the Chair at meetings of the Society. I am a new Member of the Council, and it is therefore my first appearance in this Chair. I think you will agree with me that I was fortunate to be asked to preside this afternoon for Miss Helen Monro. Hers is certainly a paper which I should have wished to listen to in any case, and I feel very privileged to be taking the Chair for her.

Miss Monro is well known for her work in her own field as an artist in glass, and perhaps even more for her great work as a teacher. She is respected throughout this country, and indeed abroad, for the work that she has done in Edinburgh. Under her guidance the Department of Glass Design at the Edinburgh College of Art has produced some of the most exciting and interesting work of our times. The only pity, as I see it, is that more use is not made of the talented students whom she has trained. I should like to see a great deal more patronage of artists in glass trained by Miss Monro particularly; and I should like to see the glass industry offering more openings for this particular craft; but this may be to anticipate to some extent the discussion which I am sure will be provoked by Miss Monro's talk. As you will see shortly, Miss Monro is not only an artist, but an evangelist for her particular craft.

The following paper, which was illustrated with lantern slides, was then read.

THE PAPER

BACKGROUND

I have the privilege and pleasure of presenting a paper on a subject which has for me intense interest, especially as a practitioner of the craft of copper-wheel engraving on glass, but also as one to whom the work of others has given the greatest delight, from that of fellow-craftsmen of the present, to that of craftsmen of past centuries, even millenia.

Wilfred Buckley (in his introduction to *The Art of Glass*, illustrated from his collection, now in the Victoria and Albert Museum) said, 'Many who have made no special study of glass get pleasure in looking at it. They would get more pleasure if without much effort they could obtain some knowledge of the history of the making of glass and of its decoration.' I do not, however, propose to embark on a historical account of the craft of glass engraving. It would be too extensive a subject, and such a survey would, in any case, be a compilation from various sources, papers, books and collections more or less easily accessible to the student; sources with which I have no doubt many of you are familiar.

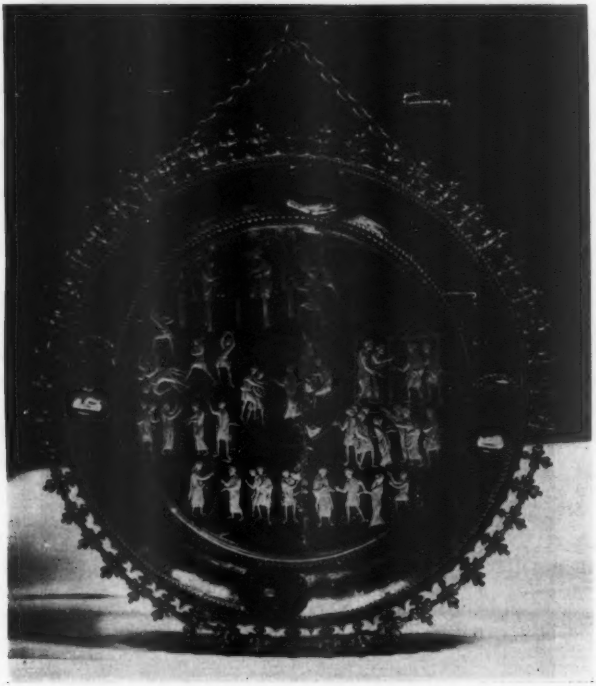
It is my regret that the active life of a practising craftsman, with its urgent demands for production, leaves little enough time for such studies. But I think

Diatreton (cage-cup) excavated at Niederemml an der Mosel, 1950, 3rd or 4th century A.D.

it of the utmost importance that the craftsman should steep himself in these sources. No medium has deeper roots, longer history, richer or more suggestive and stimulating traditions than glass.

In his introduction to the Catalogue of the Special Exhibition of International Contemporary Glass opened at Corning Glass Centre in June, 1959, Axel von Saldern writes: 'Each glass in the exhibition has characteristics which bind it to its heritage . . . each . . . has something different.' There is almost a parallel in human heredity. Be he never so ignorant of the work of his predecessors, the craftsman is linked with them through the demands, the responses and potentialities of the common medium, and his handling of tools so like to theirs; and his imaginative and technical resources are greatly enriched when he knows something of his inheritance.

From the point of view of the beholder the background is equally important.



The 'Crystal of Lothair', Carolingian, 9th century. In the British Museum

It gives range and definition to his appreciation and connoisseurship. He sees each artifact in its framework of affiliations and, looking closely, beyond the immediate general effect, he can recognize the distinctive quality of workmanship. The reward of the effort of study can, as Ray Winfield Smith rightly says, actually approach a feeling of vicarious participation in the original creative act. This must be particularly true of a more thorough understanding of the tools and methods of the craftsman.

In my first thoughts of this paper I considered a general historical treatment. But on second thoughts I decided in favour of a more technical and practical attack. This seemed a contribution which I could make from a more personal angle of experience.

However, I should like to show you a few introductory illustrations which have been very freely selected to indicate the range of engraving, in time, in type and scale, linking past with present and leading up to contemporary and future developments.

Jug, engraved by Alexander Mühler (or Millar) of Edinburgh. Late 19th century

An incised obsidian bowl of the eighteenth dynasty, from the collection of Ray Winfield Smith, would typify the deep roots of craftsmanship in engraving, and the link with stone. An example of the 'Diatreta' might be chosen as a supreme demonstration of the superb development of glass craftsmanship in the first centuries of the Christian era.

The 'Crystal of Lothair', work of the ninth century A.D., would illuminate the parallel with engraving on glass, as also, in a different way, would the Mexican rock-crystal skull, of the fifteenth century, where the artist has magnificently exploited the translucency and mystery which are shared by glass and rock crystal.

An example of the work of Kaspar Lehman, 1588, could be taken as marking the effective start of the modern European tradition of engraving which has continued more or less unbroken down to recent times. Many individual names are associated with this history and there is a marked evidence of individual

and local character. There is also a great concourse of anonymous workmanship, excellent of its kind.

A jug engraved by Alexander Mühler, who worked in Edinburgh and died about 1898, shows the European tradition in its later stages at the end of the nineteenth century.

The impression left on the mind by such a far-reaching background is one of immense versatility and variety, and of a continuous series of discoveries, inventions, applications and innovations. In this series of successive surges of initiative and creative energy individual personalities have undoubtedly played a leading rôle, strongly supported indeed by a large body of able, if not original, craftsmen. The artist has been constantly stimulated by successive developments in the technology of glass-making—from its first discovery, down through the invention of blowing, and through constant changes in the character of the material and the techniques of its production—offering new avenues to explore.

Concurrently there have been conditions which have encouraged the artist. The great periods of glass craftsmanship existed because in them the glass craftsman found means of existence. His livelihood depended on demand, on the social background, on the cultural climate, on taste and fashion which reciprocated with the inventions and accomplishments he had to offer.

COPPER-WHEEL ENGRAVING

The main part of this paper will consist of a fairly detailed description and discussion of the tools and techniques of copper-wheel engraving. As no fully detailed account of this appears to exist in convenient form, it may be useful to critic and craftsman to offer an outline based on my own training and experience.

The equipment is not elaborate. It consists of a very simple kind of lathe, an upright stand or head-stock carrying a revolving spindle.

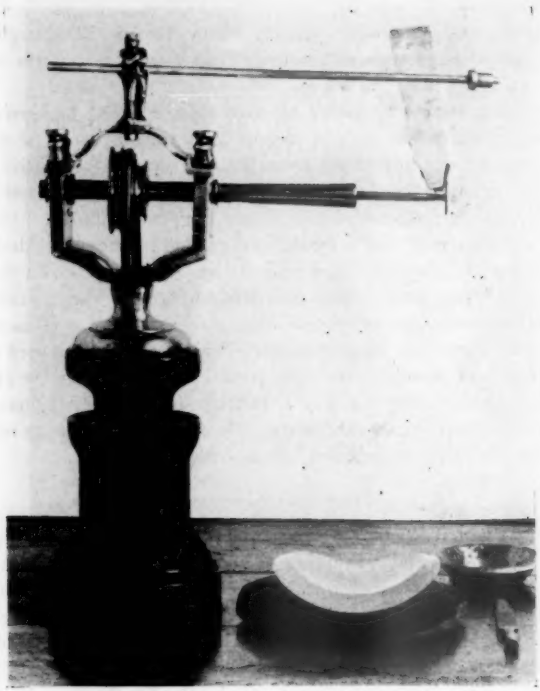
My own engraving lathe was given to me by the late William Ford Ranken. It came from the old Holyrood Glass Works in the South Back Canongate, Edinburgh, and it may, quite possibly, have been the one used by Mühler. This lathe would originally have been worked by foot-treadle: it is now driven by a $\frac{1}{4}$ h.p. electric motor with a variator which gives a continuous range of speeds.

In discussions with older engravers who have 'held by' the foot treadle, the merits and de-merits of foot power versus electricity appear fairly equal. The old style engraver certainly had his speeds very much in his own control, and he could execute a manœuvre called 'tailing off' which the electric motor cannot compass. However, in economy of human energy, the electric motor has advantages, and engravers have not been noticeably reluctant to adopt it.

Speeds range from 1,500 r.p.m. down to just ticking over—the fast speeds for truing and shaping wheels, relatively slow speeds for engraving. As it is the rim speed which counts it follows that each size of wheel has an optimum speed of its own, varying slightly with the nature of the operation.

An illustration shows another lathe also originally from the Holyrood Glass Works and dated 1870.

The bearings of these lathes are of soft white metal which gives very good



Lathe, dated 1870, from the old Holyrood Glass Works, Edinburgh; now in use in the Glass Design Department of the Edinburgh College of Art

wear, is easily adjustable and easily replaceable when it becomes worn. The fact that adjustments and replacements are within-one-man-capacity is significant for the independent craftsman.

Contemporary lathes, as used in Scandinavian works for example, are much more of a modern engineering job, and some have advantages of height, and clearance from the headstock, with a longer spindle, enabling the craftsman to handle larger pieces. (When the object is very large and heavy the work may be supported in a sling with counter-poised weight running through pulleys.)

The lathe spindle has a tapered chuck in which the spindles carrying the engraving wheels are inserted. These are of mild steel, jacketed in lead, and they fit in the chuck which has a groove to prevent turning. The lead has a kindly grip and the mild metal of the spindle is easily trued with a compound tool which also serves as a lever to eject the spindle when changing over from one

wheel to another. There are more modern types of chuck, but this old way can hardly be improved on for speed and ease of interchangeability. The whole set-up has a certain barely definable elasticity or 'give' which would not be present with an absolutely rigid lathe, and which contributes to the sensibility, the 'touch' and 'feel' of engraving.

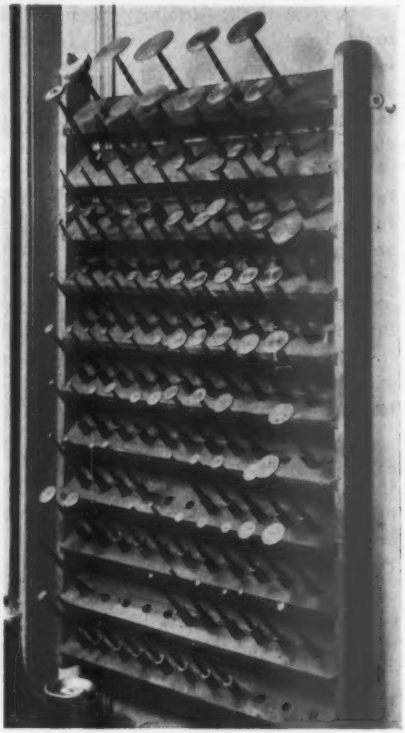
Spindles can be obtained ready-made from makers of lathes; but there is no difficulty in making one's own—dismounting the lathe spindle, setting it in a vertical position, dropping in a kind of 'thimble' to keep the lead from running out at the ejector slot, inserting the steel spindle, making sure that it is well-centred, and pouring in the lead from a ladle. A mould which matches the lathe spindle is useful as it saves time taken to dismount the lathe.

We now come to the business end of the lathe, the copper wheels of the engraver's craft. These are constantly fed with abrasive from a small dish which the craftsman keeps on his bench near his hand. The lubricant with which the abrasive is mixed is, by tradition, a combination of paraffin and colza oil in the proportion of about three to one. It is the abrasive which actually does the work, being guided by the soft copper, not actually embedded in it but effectively held.

The abrasive normally used in present day practice is carborundum (silicon-carbide) which can be obtained in a wide range of grades, screened with great accuracy. Emery powder was, I believe, graded by earlier engravers by a process of stirring and floating, very laborious and time-consuming. The grade number for average use is 400, 500 to 600 for fine work, down to 180 for roughing-in larger scale work. It is possible to use carborundum or stone wheels for blocking in if the lathe is sturdy enough to take them, or if a heavier cutting lathe is available.

An illustration shows my own wheel-rack. The rack should be within easy arm's reach and in easy view for the selection of wheels.

A considerable number of different wheels is needed, from



Engraver's wheel rack

sixty or so to one hundred and fifty or more. They vary in size from 3 to 4 inches in diameter to little things like the head of a pin, and in thickness they vary from $\frac{1}{4}$ inch to $\frac{1}{64}$ inch or so. Some are often in use, and some only occasionally for special operations.

The preparation and mounting of wheels is important. They must be dead true, must 'sleep' on the spindle. When looked at in profile when running not a quiver should be visible. They are riveted on the end of the spindle. Larger and heavier wheels should have stronger less tapering spindles and a stronger rivet and collar. Tiny wheels must have the spindle tapered finely to clear the work and may be riveted on a taper end without collar. There is a certain balance in the design of a well-mounted wheel. Careful preparation of a true circular disc of copper, perfectly flat, and with the hole dead centre, saves much time in truing, and much wear and tear on the lathe bearings. Final truing of the wheel, provided that the spindle is running true, should not take long. A sharp steel blade is firmly held at an angle to throw the little slivers of copper aside, and not into the eyes, and it lightly and steadily nicks the wheel into shape.

The edges of the wheels vary in profile according to the work each is designed to do. This shaping is done with a file, which must not be used unless the wheel is already true. (The file need not be wielded as in filing a stationary object, since the turning wheel files itself. Only a slight movement is needed to eliminate the little grooves which might be made by the teeth.) A run through very fine emery paper, and lastly through pumice stone, gives a good clean finish.

Handled correctly, with care in taking from rack and inserting and removing from the chuck, and used correctly in engraving, the wheels should need little further attention and will stay true indefinitely. They do, however, wear down and they have to be replaced. Small and thin wheels wear down most quickly and it is good practice to have plenty of these in the rack. Hammering, of course, hardens the copper and it is usual to do this before mounting, with care taken to hammer all over, otherwise the wear will be uneven.

If all this sounds laborious I can but assert that a wheel you have made yourself and shaped to your exact need has become a most sensitive instrument; you have made it almost a part of yourself.

The varieties of profile are endless, but they fall into only a few general groups. Some wheels are flat at the rim, some are more or less rounded or U shaped, some are V shaped. If you look closely at engraving you will be able to differentiate the distinctive traces of the rounded wheel in the round spots, or ovals, of the V wheels in leaf-like shapes or longer V grooves, and of the fine U or V shapes in lines which may be bold or almost incredibly fine. More complicated forms may not be so easy to analyse into these simple mathematical components. The flat-sided wheel may be used with a sideways movement or slip-cut to make swerving or wavy forms which may be accented by the engagement of the edge of the wheel. The light surface abrasion produced by a large wheel in this way is characteristic of the rhythmic fern patterns popular in Victorian times.

The complex intaglio modelling of 'deep' engraving is done by moving both

Diagrams showing various types of engraved cut and appropriate wheels

along and side-ways and round and round, using a wheel more or less flatly rounded.

The term deep engraving does not necessarily imply great depth. In fact it is undesirable to force the depth to the extent of realistic solidity since the play of light in glass makes this seem exaggerated. It is quite astonishing how much drawing and form may be expressed by quite slight variations in depth. This applies also to engraving in relief, or *hoch schnitt*, and a comparison here may be made with the refined modelling of sculpture in low relief.

A diagram illustrates the various types of wheel, and the effects produced.

In addition to the copper wheels there are also polishing wheels of cork, wood or lead. The cork produces a very soft effect, the wood a brighter, and the lead a brilliant finish. Polishing media are fine pumice powder, jewellers' rouge, or other polishing powders obtainable from suppliers of optical materials. Rubber wheels impregnated with diamond dust are now also available for polishing.

The action of the copper wheel is almost automatically precise and the lines and hollows it makes have the most exquisite exactness. With fine abrasive this can have the most incredible delicacy. Even with a coarser abrasive the form is still firmly controlled and directed.

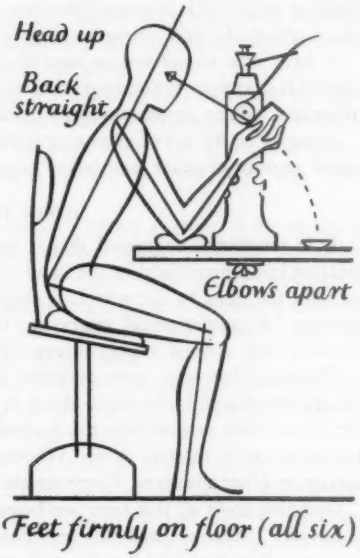
In a study of glass-cutting technique Ray Winfield Smith says: ' The fact of rotation introduces . . . a degree of geometric accuracy which can be achieved in no other way . . . In fact, the rotation techniques may even be described as phenomenally self-correcting.' The copper-wheel engraver finds, in fact, that the wheel clings to the hollow it has begun to make and needs only the gentlest guidance to extend the form of the hollow as he wishes. The accurate geometry is creatively liberated.

Thus the apparent difficulty of seeing what one is doing is not so great as it seems, though the glass is behind the wheel and a little pool of abrasive surrounds the immediate point of contact. The engraver works as much by touch as by sight; he 'sees' with the tips of his fingers. There are, however, various methods of 'marking on' as guidance. The design may be drawn on the glass with process white to which a little gum arabic has been added, or indian or lithographers' ink may be preferred, and the drawing may be protected from rubbing off by a thin coat of clear quick-drying varnish. Alternatively it may be very lightly 'scrolled' in with a very small engraving wheel and this is, of course, indelible. It must be carefully done not to over-run the edges of the finished work. Marking on with a diamond point runs the risk of making an impression too deep to be eliminated in the finished work if the engraving is fine.

The precision and control of engraving is inherent not only in the wheel itself but in the poise and action of the engraver. He is seated at the bench in a position which brings his line of sight, directly past and just below the spindle at the point of attachment of the wheel, to the contact point on the rim of the wheel. His elbows are placed on the bench (on cushions) so that when he brings the glass into contact with the wheel he is in an attitude of ease. Height and angle of seat, height of bench, and height from bench to spindle should be adjusted so that there is no discomfort or strain.

In obviating strain the lighting is important. It should be adequate but diffused. The engraver frequently faces a window, and a small mirror may be arranged to reflect daylight up to the glass. Even north lighting is desirable. In our climate artificial lighting may be preferable. This may consist of a strip or panel of obscured light in the mirror position with equalizing light overhead.

The glass is not held in a rigid grip. The position of the hands holding the glass is, of course, modified by the size and shape of the object being engraved. The main point is that the glass should be completely under control, yet able to be moved freely in any direction. As a general rule the glass should rest on the tips of the fingers, the fingers should be bent and the wrists bent inwards, with the flexibility of a coiled spring.



The correct position for engraving

The pressure exerted is light, but firm and even.

There is nothing really complicated or frustrating in all this. It is in fact an ideal combination of stability and freedom. The position and action become unconscious, second-nature. The patience called for is not plodding or weary, but a sustained, effortless concentration. The mood is relaxed and confident, tinged with exhilaration.

The precision of engraving is not laborious or meticulous. Derived from the Latin, *metus*, this word has an undercurrent of fear; but, with the right approach, there should be no apprehension, or anxiety, or fear of making a mistake.

Above all, engraving is not 'bitty' or 'niggling'. The patterns and forms are built up freely and naturally from one another. It is possible to build up a complex form by nibbling away with a small wheel in innumerable timid touches, but this method is far from the bold choice of a suitably large wheel to state the main form firmly, using smaller wheels only when it becomes necessary. The right approach gives unity and wholeness to the work. Even when the scale is minute, and though the nuances of depth and modelling may be infinitesimal, good engraving still has finely true relationships of weight, accent and balance.

All through good engraving runs rhythm and movement. It is the record of a gesture. It has an entrancing elegance, a disciplined dancing impulse from toes to finger tips. It has tempo and alertness. The lathe is a machine, it is true; but it might rather be called an instrument, as flute or violin is an instrument for

making music; if it is a machine then it is one in the classic sense, the machine from which the god emerges—*deus ex machina*.

I have now completed as carefully as I could an account of the tools and methods of copper-wheel engraving within the limitations of words, pictures and diagrams, where demonstration would be preferable.

A paper on the art of glass engraving would, however, be incomplete without some account of other methods of engraving or abrading the surface of glass.

OTHER TECHNIQUES

It is sometimes suggested that it would be easier to engrave with a wheel-bearing instrument held in the hand—to take the wheel to the glass rather than to hold the glass to the wheel. It may have been apparent from the foregoing account of copper-wheel engraving that it provides conditions of stability, freedom and control which, in my own view, are incomparable.

There is, however, now available a great variety of grinding tools either electrically driven (with hand-motor or flexible drive) or driven by compressed air. Their scale ranges from the fineness of a dentist's drill to sizes suitable for sculpture on a massive scale. Wheels are of compositions of carborundum, aloxite, or other abrasives. There are also diamond-impregnated wheels and drills.

Grinding tools of this type are being used to a considerable extent by contemporary craftsmen, and this technique has merits of its own. I feel strongly, however, that it should not be confused with true copper-wheel engraving, or used to try to produce similar results, particularly in intaglio. Possibly its merits are more graphic, especially in small work. Its freedom of movement is quite different from the disciplined freedom of the fixed wheel. In a large-scale work the application of the free wheel has obvious advantages. Large sheets of glass are unwieldy, although the skill of the *brilliant-cutter*, a race happily not entirely extinct, in controlling, in contact with the fixed wheel, the movement in slings of very large sheets of glass, is phenomenal.

Sculptural treatment of sheets of relatively thick glass has not been much explored in this country and I should like to see it developed. It could integrate well with contemporary architecture. Nor has sculpture in the round been taken far, though the material for this should not be beyond the power of modern glass-making.

In strong contrast with large-scale grinding stands the use of diamond-point used either to draw fine lines, or fine stippled dots produced either by impact or pressure. The term diamond-point engraving in current usage also covers the use of hard steel points of alloys which were not, of course, available to earlier engravers.

The Romans engraved lines on glass with a sharp point of unknown material. In mid-sixteenth century 'all kinds of foliage and other fine features are scratched on the fine and smooth Venetian glass with a diamond'. It was resorted to for tendrils and details by Lehmann, Schwanhardt and other pioneers of glass engraving in the seventeenth century. Never and nowhere did it reach such a peak of virtuosity as in Holland in seventeenth and eighteenth centuries,

where it was practised mainly by amateurs, many of whom were women. Greenwood, Schouman and Wolff were masters of the stipple method, evolving a chiaroscuro so fine it seems like smoke on the glass.

At the present time the work of Laurence Whistler stands in a class by itself, absolutely *hors concours*, not only for extreme technical accomplishment but also for its poetic content. The work of the Swiss artist, the late Gertrud Bohnert, who developed her technique in isolation during the war, had also great distinction.

Diamond-point engraving is most evidently a highly personal form of art. It is also a graphic art. It lies on the surface and does not interrupt the line of the glass. On the other hand it does not enter into it and blend with it, and exploit the play of light in depth which is the exclusive attribute of glass as a medium. And though, in the hand of a master, it has the utmost distinction, it can lend itself to a meretricious facility which is to be deplored.

There is an electrically driven vibratory tool with a pecking movement which gives effects roughly similar to diamond point on a very much larger scale. Its possibilities, so far as I know, have not been exploited.

Lastly, with no historical tradition behind it (if we except the work of wind and wave on rock and tree) there is the technique of sand-blasting. The process was invented by Benjamin Tilghman of Philadelphia just ninety years ago, inspired by the action of waves of the sea on wooden sea-walls. His patent covers the application of the abrasive action of sand, propelled by water, steam or air, to glass only as one among other hard materials, and sand blasting has many other uses.

For sand-blasting glass the equipment consists of an air-compressor and a hopper to contain the abrasive and deliver it through a valve into the air-stream from the compressor. The combined jet passes through a hose to the nozzle which directs it as required. The operation takes place in a cabinet fitted with an exhaust system which extracts dangerous dust from the air. The heavier abrasive particles fall to the ground and may be re-used until they lose their cutting power. The operator may work inside the cabinet, and if so he will need a helmet supplying breathable air and will wear protective clothing. Preferably he may work from outside, inserting his hands through a rubber lined opening and wearing rubber gloves, and viewing the work through a panel of glass.

The abrasive may be carborundum, or crushed flint, or chilled iron shot. Sand is no longer used, though the name remains.

Parts of the glass which are not to be abraded are protected by a resist which must be resilient and adhesive. The commonest is glue-paper; but the new tacky tapes, obtainable and manageable in widths up to 20 in., are convenient. The whole surface is covered with resist and the design is cut out and stripped where necessary. It may be traced or drawn or cut free-hand. Metal stencils may be used for repetition work, or a resistant paste stencilled on to paper which is then stuck down on the glass. Resist may also be freely painted on, and I feel this would have great possibilities for the original designer.

The range of scale in the application of this process is great, from fine work

on a wine glass to coverage for doors, windows or walls. The range of possibilities it offers to the designer is also great, from the merest shallow tracery on the surface to excavations of considerable depth in thick glass, with all the consequent play of light in these. The different types of abrasive give different textures. The angle of play of the nozzle gives interesting complexities of form, and sand-blasting need not be merely a series of flat levels. It is perhaps regrettable that too few designers execute their own designs, as it is only in handling the nozzle oneself that one realizes the flexibility of this, apparently, at first sight, mechanical process.

CONCLUSION

This completes a survey of techniques which present a very extensive range of precedents and possibilities.

The Society's request for this paper shows that a new interest in glass engraving is being taken, and that there is noticeable activity in this field. I believe that we are feeling the swell of one of those waves of initiative and invention to which I referred in my introduction. This impulse must be met by a reciprocating wave of appreciation and encouragement if it is to reach its peak. I believe that we have practising and potential designers and craftsmen who need not fear comparison with craftsmen of other periods or other countries, and that (as in *1066 and All That*) this is a 'good thing'.

Now, to set up as an independent practising craftsman takes a good deal of initiative. Even the simple outfit for copper-wheel engraving takes a modicum of capital (and other techniques may need a considerable investment of time and money). There is no great sales organization behind the individual. In short, he needs courage, capital and contacts.

For copper-wheel engraving in particular the age of courtly protection and patronage is past and the conditions of contemporary society are different. The responsibility for keeping alive and revitalizing skills which may have value for contemporary life rests on a wider base. It would be a good thing if more individuals of standing and taste and sufficient means would more often commission important original individual works of art, to keep, or to give, or to commemorate occasions; but it is, at the same time, reasonably within the reach of individuals of more modest means to have the joy of unique 'bespoke' possessions. Copper-wheel engraving, with its close relation between client and craftsman, is especially suitable for the introduction of the personal factor. It may be a far cry from the covered goblet encrusted with baroquerie or chinoiserie to a simple monogram or initial neatly done and exactly placed on one dish, or service of table glass. Possibly the latter is more consonant with the spirit of our own times.

The responsibility of patronage has also devolved on, and happily is increasingly recognized by, public bodies and other large organizations.

The acceptance of such responsibility necessarily implies discrimination: the recognition and appreciation of sound craftsmanship and originality at their true value: conversely, the discouragement of short-cut methods, amateurism and under-valuation. Under-valuation is one of the besetting temptations of the

Crystal goblet engraved by Helen Monro for presentation to Prince Giovanni Ginori Conti, President of the Third International Congress on Glass, Venice, 1953. The arms are those of the Conti family

younger craftsman (comparatively defenceless and anxious for his daily bread). It could involve him in a vicious circle of hurried work and limited or frustrated development.

Responsibility also rests on the glass industry of this country. I have emphasized the individual aspect of engraving, and it is possible that I may have overemphasized the independently practising craftsman. It would be sad if mass markets, and mass methods of production, were allowed to result in the elimination of individuality. But these two aspects, the industrial and the individual, are not mutually antagonistic or exclusive. Even in independent practice repetition work, and a certain amount of routine, is an accepted part of the game. Repetition need not be dreary or mediocre, nor need it reduce the craftsman to a mechanical level.

The use of engraving in industrial production could easily be more enterprising

and inventive, less backward-looking in motives and style, bringing engraved glass more in line with contemporary design in ceramics, textiles and furniture.

The application of engraving could possibly be much more free and bold. The delicate refinements of engraving are not eye-catching; yet its delicate detail might be in interesting contrast with the broader effects of the contemporary background.

Changes in the economic structure such as the recent developments in the European market present a challenge to industry which can only be met by a fundamental re-orientation of ideas about design. (This applies, of course, not only to decoration, but to design in every sense.) The challenge will not be met by belated imitation of external developments, but only effectively by an essentially original drive. I would suggest that some of the fresh, new, fertile impetus and stimulus needed could come from the unsubsidized, spontaneous, individualistic, creative activity which is in being and gathering momentum: that the industry would benefit by the absorption, at responsible levels, of individuals of independent and vivid personality who would give character to the product.

A renascence will not come from dictation, or decisions in committee. It will only come from practising artists in glass. And as glass-making inevitably requires the co-operation of a group, there must be the closest possible contact between one craftsman or designer and another to achieve real unity and complete integration. This has not been fully developed in the structure of our industry.

We have nothing quite comparable with Steuben, Leerdam, or Holmegaards. Behind Steuben, of course, there are tremendous resources on a scale only possible in America; behind Leerdam an enterprising internal educational project, fully self-rewarding. We have nothing yet comparable (in involvement of personality) to Venini, Barovier, Strømberg (for the Baroviers, father and son, glass-making in direct line of inheritance of centuries, for the Strømbergs, glass-making a family way-of-life). We have no names yet with quite the impact of Wirkkala, Sarpaneva, Heesen, Lütken, Johannsen or Jütrem. But we have, I do believe, talent, even genius, which must somehow or other find expression and scope.

Alongside the basic, run-of-the-mill, repetitive products of the glass-works stands the *pièce unique*. We have done too little about this. These things, which have interest and value as single un-repeated units, are not competitive, cost-conscious, or commercial in the ordinary sense, though they have a substantial market: they are not merely for prestige, which is, after all a commercial value; they need not be costly, or impressive in scale; they might be called creative research; and they are necessary for the health and wholeness of the industry. Occasional and spasmodic efforts of this type are vitiated by the absence of the deep background of experimental investment of time and thought and effort needed for creative evolution.

This provocative broadside is a conclusion I have been unable to avoid.

In this paper I have only 'abraded' the surface of glass. It is, in recent student argot, undoubtedly a 'fantabulous' material.

DISCUSSION

MR. HUGH WAKEFIELD (Victoria & Albert Museum): I should like to thank Miss Monro for an extremely interesting account of her craft. It seems to me that glass engraving is one craft which, more than most others, the layman does need to have some understanding of; since a knowledge of the methods used by the engraver does add so much to the layman's appreciation of the work which is produced. I was very interested to hear Miss Monro refer to Alexander Millar. Millar was one of the quite numerous engravers who worked in Edinburgh during the nineteenth century. It is significant that Miss Monro works in Edinburgh, and to me she appears as a reviver of this craft which has been associated especially with Scotland during the last 100 years. I have one point I should like to raise, and that is the relationship between copper-wheel engraving, with which Miss Monro is mainly concerned, and the technique of glass cutting. In both techniques the wheel is used; but in a different manner, since in cutting the operator pushes the glass on to the wheel instead of pulling it up on to the wheel. It is not always clear why the cutter pushes his glass on to the wheel, and perhaps Miss Monro would say a few words on that point.

Associated with that question, I should also like to know her views on the combination of different sorts of engraving and cutting on individual works of art. She rather implied, I think, that one should always keep to one technique with a particular work, and not attempt to combine techniques.

THE LECTURER: If I may take the last point first—I think that different techniques may be combined if it is done with discretion, and the whole design is truly integrated. The other point: cutting over or under the wheel—it would take rather a long time to explain just why, although we cut on top of the wheel, it is better to engrave under the wheel. When cutting on top of the wheel you can see through the glass and watch the shape of the cut developing. Actually some cutting is done underneath; it depends on the type of object which is being cut and the scale of the work. One point about cutting on top of the wheel is that the craftsman can rest the work on the wheel and when the piece is heavy this may be an asset.

MR. JOHN GAYLARD: With regard to stained glass window technique, have you any experience of enamelling or lustreing on glass and then dusting gently by sandblast gun to get a cameo effect? In other words you engrave the basic glass then apply another colour and then dust the colour off to obtain a cameo effect?

THE LECTURER: Yes, we have used 'flashed' glass, which has a relatively thin layer of coloured glass on a clear ground, and also clear glass which has been 'silver-stained' to a golden colour on the surface. By cutting, or sand-blasting the coloured layer away to varying degrees, or completely, very interesting effects can be obtained.

MR. DAVID PEACE: I do not know whether I speak for other glass engravers here, but it does occur to me that we work rather as a scattered community. Miss Monro has come all the way from Scotland, and I have come 150 miles to hear this lecture—and I am very glad that I have. I look forward to reading the lecture in print, and to enjoying again some of the delicious phraseology which only a woman glass engraver could have used. A phrase I made particular note of was 'a disciplined and dancing impulse'—who but a woman engraver could have put her craft in that particular way?

I should like to ask her, though, what she meant by the words 'rotation techniques are phenomenally self-correcting'? Also, what is it particularly that we can learn from the work of Verzelini and Anthony de Lysle? His engraving seems to me to be very freely scratched on. Finally, a very practical point—how does she mark her design on the glass to start with?

What Miss Monro has achieved this afternoon is what she alone could achieve—that is, to increase the understanding among the widely scattered engravers, and understanding between them and the rest of the community; she has in fact increased in a wonderful way our understanding both of craftsmanship and connoisseurship.

THE LECTURER: I am not quite sure if I have all your points correctly. I will take the last one first. I think it is high time we had a Society of Glass Engravers, and I should be very glad to be contacted on that subject.

I cut out the part about marking glass in my paper, because I realized I had written a book instead of a lecture. You can mark on with process white mixed with a little gum; you can protect that with clear quick-drying varnish, and the varnish will prevent the drawing from rubbing off on a long job; but on a really long job you do a little scroll cut just inside the edge of your work and that will not rub off. Usually I just put a little mark here and there, and do the engraving freehand. Of course, when you put a mark on the glass, as soon as you start engraving you take the mark away.

About the work of Anthony de Lysle—I think that sort of engraving is very free and spontaneous; it is charming, but I do not personally feel impelled to do any more of it.

That phrase about rotation techniques being self-correcting was a quotation from a paper by Ray Winfield Smith on glass cutting techniques (I am not sure whether it has been published, because I saw an advance copy), and it seemed to me to hit the nail on the head admirably, to illuminate how you engrave by feel'; you make one little cut, you slip into that one and draw it along and you cannot go wrong.

MR. JOHN SKELTON: I would like to ask how the abrasive is applied to the wheel?

THE LECTURER: There are two ways. You can dip the wheel in the abrasive, or you can dip your finger in the abrasive engraver and dab it on the wheel with the tip of the finger—that is the method generally practised in the industry. I like best just to dip the wheel in the abrasive at the right place, tipping the dish so that the free lubricant runs back, and dipping just where it has receded. This is done very frequently, almost for every cut.

MR. EDWARD MEIGH (Glass Technical Services Ltd.): As one who has lived for many years with the automatic machines which manufacture the glassware, may I make two comments? First, I think everybody connected with glass is indebted to the lecturer for having, for the first time, put in writing a description of this art which is so much her own. Secondly, I am very forcibly struck by the care which has been given to the relationship between the working posture of the worker and his equipment, and that concerns us very much in the factories where glass is made by machine. I feel certain that students of the modern human science of ergonomics would be delighted to have that diagram, which was shown, which depicted the relationship between the worker and the machine. I am quite sure that in this field we have a lot to learn from the care given by artists to work environment.

THE CHAIRMAN: I should like to thank the last speaker for that point; it is a very good one which I shall take back to the Editor of the magazine for which I am partly responsible, a magazine, perhaps known to some of you, which has been taking some interest in ergonomics recently.

Well the time has come to thank Miss Monro more than formally for her admirable paper. I agree so well with what the gentleman on the left said about her phraseology. Early in her paper, she said, 'Concurrently there have been conditions which have encouraged the artist. The great periods of glass craftsmanship existed because in them the glass craftsman found means of existence. His livelihood depended on demand, on the social background, on the cultural

climate, on taste and fashion which reciprocated with the inventions and accomplishments he had to offer.' Later she said that she hoped that the crest of the wave is coming up again and that there will be a renewal of interest in, and demand for, the art of the glass craftsman. I sincerely hope she is right.

I think Miss Monro's suggestion that there might be an association of artists in glass was a good one, and as Director of the Council of Industrial Design, I should myself like to make a bid for the first exhibition of the work of that association. We have a showroom in the Haymarket and I for one would be delighted to give house-room to these craftsmen.

Miss Monro has been particularly modest this afternoon; she has hardly mentioned herself or illustrated her own work. There is a record here that I brought with me, a fine catalogue produced by the Corning Glass Company in America of an exhibition of modern international glass which they held last year. England is well represented, but the interesting thing is that so much of the British representation in this catalogue is owed directly or indirectly to Miss Helen Monro's own workshops and own students. For that we should be very grateful to her.

The vote of thanks to the Lecturer was carried with acclamation, and the meeting then ended.

THE EXPLORATION OF OUTER SPACE

The Trueman Wood Lecture by

A. C. B. LOVELL, O.B.E., F.R.S.,

Professor of Radio Astronomy, University of Manchester, and Director of Jodrell Bank Experimental Station, delivered to the Society on Wednesday, 24th February, 1960, with Oswald P. Milne, F.R.I.B.A., J.P., Chairman of Council of the Society, in the Chair

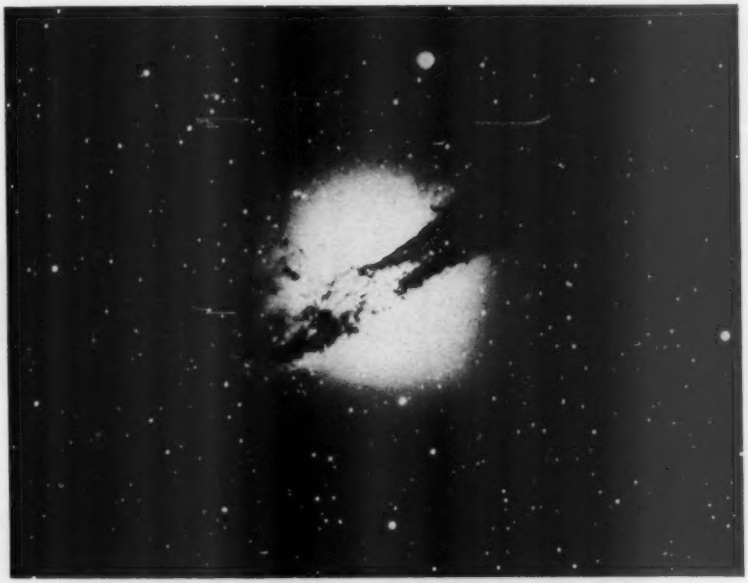
THE CHAIRMAN: I sense an air of expectancy about this lecture! You will all know Professor Lovell as a very distinguished astronomer, and as Keeper of the greatest radio telescope in the world. It is a great thing to be keeper of the largest telescope in the world, but perhaps it is an even greater thing to know how to use such a complicated affair. Dr. Lovell can follow the courses of sputniks and luniks, and probably with his team of experts has probed further into the vast spaces that surround us than anybody else. Not many years ago, fifty or sixty perhaps, imaginative writers like H. G. Wells were exciting us with stories about space travel. As a boy I remember reading those stories with avidity. As far as I remember, you were to be put in some sort of contraption and either shot out of a great cannon up to the moon or else, having somehow defeated the powers of gravity, you were to leap off the earth and arrive in space, or—if you wished—on the moon. Well, I have no doubt that we all thought those stories very exciting, but not things which would ever happen. But discovery moves at a great pace these days, and mankind is sending up into space projectiles which are circling the world, and which have circled the moon and have hit the moon full in the face. So for good or ill we have violated that tranquillity which we have always associated with the moon. We shall go much farther in these matters I am sure, for having opened the door a crack, humanity will never stop in its quest.

The following lecture, which was illustrated with lantern slides, was then delivered.

THE LECTURE

1. INTRODUCTION

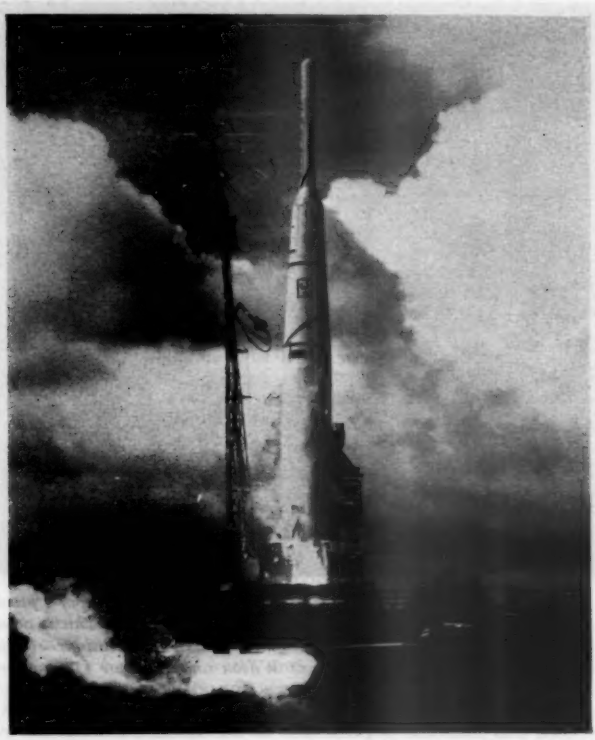
Five years ago on the 23rd March, 1955, I had the privilege of addressing this Society. The title of my lecture was 'Radio Astronomy', in which I described man's new techniques for the exploration of space made possible by the discovery that radio waves were reaching the earth from outer space. Since the dawn of consciousness man has used his eyes to study the stars in the sky, and for the last 300 years the development of the optical telescope has provided him with increasing powers of penetration into the heavens. In the decade before the Second World War the great optical telescopes on Mts. Wilson and Palomar in America photographed systems of stars and galaxies from which the light had taken a thousand million years to reach us after its journey through space. It



A photograph taken with the 200-inch Mt. Palomar telescope of a peculiar object (N.G.C. 5128) in the constellation of Centaurus. This is a radio source and is believed to be a case of two galaxies in collision. (Reproduced by permission of the Mount Wilson and Palomar Observatories)

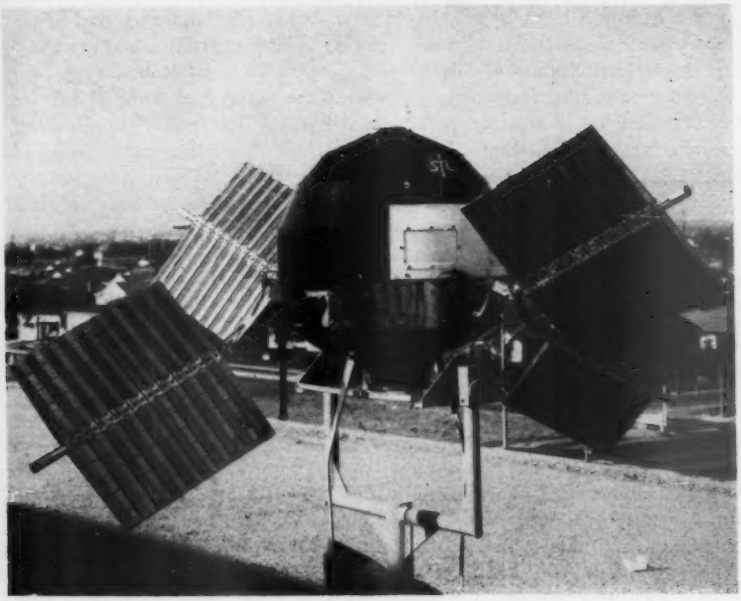
seemed then that man was in possession of the ultimate tool for the exploration of space and that he would soon be able to reach a final decision on the processes of evolution and origin of the cosmos.

During those wonderful years of discovery the astronomers were almost intoxicated by the power of the optical telescope combined with the photographic plate and the spectroscope. Man had been blessed with senses of sight which enabled him to see the light emitted by the stars and galaxies, and although our terrestrial atmosphere was opaque to anything but the colours of the rainbow, there was no serious inquiry or anxiety as to the extent of any limitations which this might entail on our knowledge of outer space. However, at the very moment when these telescopes were in the full flood of discovery an American engineer, Karl Jansky, who was investigating thunderstorms with a radio receiver, made a simple observation which was to effect a transformation in the techniques for the investigation of outer space. He found that the background noise in the receiver, which should have remained constant if it was all produced in the components of the receiver, varied systematically throughout the day. Jansky noticed that this daily variation occurred within a period of 23 hours 56 minutes, which is



Man's first attempt at a lunar probe. The moment of launching of a Pioneer space probe from Cape Canaveral, Florida. The first effort at a lunar probe in August, 1958, exploded 80 seconds after lift off. Subsequent launchings met with varying success. Pioneer IV (March, 1959) passed a few thousand miles from the moon and is now in orbit around the sun. The Russian Lunik II (13th September, 1959) made impact with the moon and Lunik III (October, 1959) photographed the hidden side

the period of rotation of the earth with respect to the stars. The elegance of the observation lies in its simplicity and in the unambiguity of the conclusion that whatever was responsible for the daily variation must originate from regions of space outside the solar system. This work encountered all the classic hindrances which nearly always accompany great scientific discoveries, and now it is with incredulity that one reads that Jansky's employers transferred him to other work, and that for nearly ten years interest in the subject was sustained only by the efforts of Grote Reber, who built apparatus in his own garden while carrying on full time occupation in an unrelated subject. In fact, Jansky and Reber had



The payload of Explorer VI, the successful American satellite launched in August, 1959, into an elliptical orbit which carried it on a circuit of the earth out to a distance of nearly 30,000 miles. The paddle wheels containing the solar cells for recharging the batteries can be seen. A similar payload was launched in March, 1960, as Pioneer V, and is now in a vast orbit around the sun between the earth and Venus

shown that the light from the stars and nebulæ was not the sole means at man's disposal for investigating the cosmos, but that this so-called 'optical' window in the earth's atmosphere was accompanied by a much more extensive window at longer wavelengths in the radio wave region, through which radio waves were reaching the earth from outer space. The work of these pioneers remained almost unknown and the significance of the discovery was certainly not understood until the technical developments of the war stimulated a few scientists to study the heavens in this region of the spectrum. Now, radio telescopes are almost as common as optical telescopes, and astronomy is in the throes of a revolution which can reasonably be compared with that which arose from the investigations of Galileo.

As the technical legacies of one war were being woven in to astronomical instruments, the fear of another conflict drove the Great Powers into the expenditure of unprecedented sums of money for the development of ballistic rockets. After ten years of progress towards purely militaristic ends, both the U.S.A.

and the U.S.S.R. found themselves possessed of rockets which could not only throw a hydrogen bomb across the Atlantic, but if otherwise employed might succeed in the almost fictional dream of placing in orbit an artificial earth satellite. The dramatic realization of this feat by the U.S.S.R. in October, 1957, was followed by a conflict for supremacy between the U.S.S.R. and the U.S.A. on a scale which could scarcely be maintained in the interests of fundamental research. Nevertheless, these efforts have provided astronomers with means of conveying their instruments to regions of space where the earth's atmosphere ceases to influence or absorb the radiations reaching us from the sun and outer space.

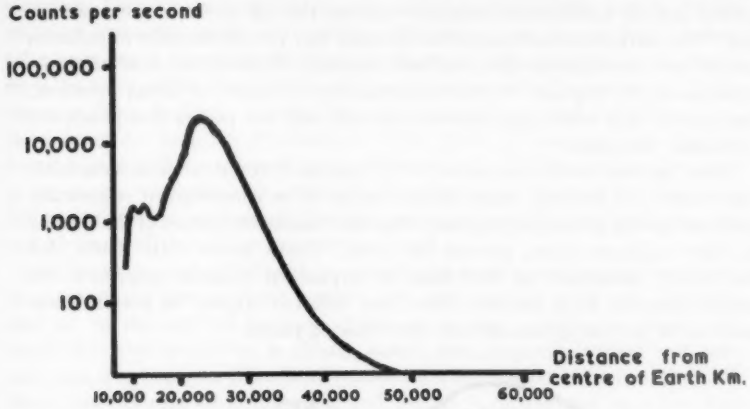
During the span of our own lifetime the possibilities for the exploration of outer space have undergone two transformations, one by virtue of the techniques of earth-based radio astronomy, and the other through the opportunities offered by satellites and space probes which can carry the instruments of the astronomer in at least a temporary escape from their earthbound environment.

2. WHERE DOES OUTER SPACE BEGIN ?

The earth is 93,000,000 miles from the sun, the light from which takes 8½ minutes to reach us. The most distant planet Pluto is over three and a half thousand million miles away and light from the sun takes 5 hours to reach it. Dimensions of this order define the regions of interplanetary space, which contains the sun and its family of planets, including the earth and the moon. Compared with the space of the stars and the galaxies, interplanetary space is minute, but for us on earth it is the beginning of outer space in the sense that the earth and its environment is a minor partner exerting negligible influence on the conditions in it.

Only a few years ago it was believed that the geophysical environment of the earth was extremely localized. At the altitudes of a few miles above the earth at which modern aircraft fly the air is already too attenuated to support life without pressurized cabins. At 70 miles the air is extremely thin by terrestrial standards, but fortunately it is still dense enough to burn up most of the meteors which bombard us from interplanetary space. In this region too, some of the radiations from the sun are absorbed and have a semi-permanent effect on the basic condition of the air, in that an electrified, or ionized, region surrounding the earth is created. These ionospheric regions extend upwards to a few hundred miles with a complex and variable structure. They have a significant effect on our daily lives because it is in these regions that the radio waves are reflected which make possible round-the-world radio communications. The point where the uppermost of these regions disappears—say at 300 or 400 miles—was, until recently, generally believed to be the region where any significant effect of the earth and its atmosphere vanished.

The first and major scientific aim of earth satellites was to carry instruments to this near region of outer space, and one of the primary desires was to study the solar radiations and other incoming particles and radiations before they were absorbed or otherwise interfered with by the earth's upper atmosphere. The first



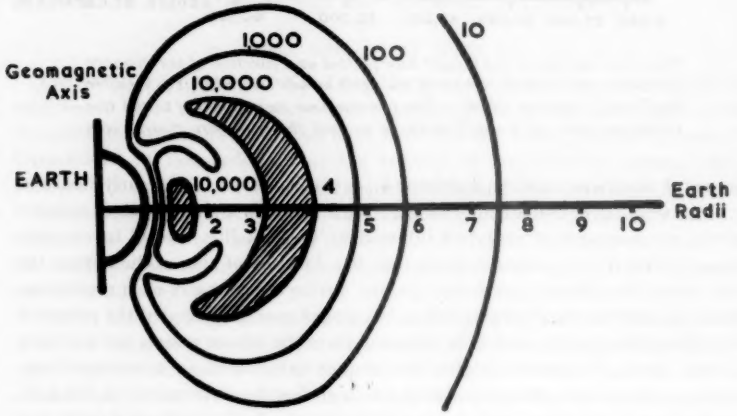
The counting rate of the Geiger tube plotted as a function of the distance of Pioneer III from the centre of the earth on 6th December, 1958, (after Professor J. A. van Allen). The two maxima corresponding to the two radiation zones of trapped particles around the earth are clearly seen

successful American satellite, Explorer I (1958), launched in the early hours of 1st February, 1958, contained amongst its instruments a simple geiger counter for the measurement of radiation intensities. This satellite moved in an orbit with a period of 115 minutes, such that the distance of the satellite from the earth varied from about 370km. to 2,500km. during the course of each revolution. When the satellite was below 1,000km. the geiger counter recorded the radiation intensities which might have been expected from the known cosmic ray intensity in outer space. At greater heights the counter behaved in an anomalous way, and at 1,100km. the counting rate became so high that the instrument was blocked. Any obvious explanation, such as that the apparatus had developed a fault, was rejected because the system behaved normally at the lower altitudes and the phenomenon repeated on each orbit. Van Allen, who was responsible for this experiment, was forced to conclude that as the satellite moved into the 1,000km. altitude region above the earth, it encountered intense radiation, and that within a few hours it was exposed to a dose which would be the limit of human exposure for a whole week. Now this radiation was penetrating the stainless steel hull of the satellite and the walls of the geiger counter, and van Allen concluded that it could not be electromagnetic radiation but must be corpuscular, probably electrons or protons constrained under the influence of the earth's magnetic field.

The existence of this intense radiation was confirmed by Explorers III and IV (launched in March and July, 1958), and some information was obtained about the latitude effects which strengthened the view that the radiation was corpuscular, trapped in the earth's field. However, the Pioneer deep space

probes and the Luniks were required to study the full extent of this radiation belt. The instruments in these probes revealed that yet another zone of radiation existed at a much greater distance from the earth. Whereas the zone originally encountered by Explorer I was concentrated at a height of about 2,000km., the heart of this outer zone was not reached until the probes had penetrated 20,000km. into space.

There has been much study in the U.S.A. and the U.S.S.R. of these remarkable discoveries, and although many details remain to be completed, it is generally believed that the accompanying diagram gives a reasonable picture of the location of these radiation zones around the earth. There seems little doubt that the primary constituent of both zones is corpuscular radiation trapped in the earth's magnetic field, and that they have different origins. At present there seems to be general agreement over the following points.



Intensity of the trapped radiation around the earth (after Professor J. A. van Allen). This is a cross section of a 3-dimensional figure of revolution around the earth's geomagnetic axis. The contours labelled 10, 100, etc., are the true counting rates of a Geiger tube carried in Explorer IV and Pioneer III. The horizontal scale is the distance from the centre of the earth in terms of earth radii (6371 km.)

(*a*) The inner zone probably consists of a penetrating component of protons with energies up to 100 MeV. together with a less penetrating component of electrons up to 1 MeV. The numbers of these particles in the zone are immense compared with anything previously anticipated. Existing figures are that the zone contains 2×10^4 protons/cm.^{2}/sec. with energies greater than 40 MeV., and 2×10^8 electrons/cm.^{2}/sec. with energies exceeding 2 KeV. This radiation zone seems to be relatively stable and all the investigations made since its discovery have given similar results. There are two views on the origin of this zone of

particles. There is evidence from other experiments that the sun ejects the nuclei of hydrogen atoms—or protons—with energies up to 100 MeV. during solar flares and it is possible that these penetrate to a distance of about 2,000km. from the earth, where they come under the predominant influence of the earth's magnetic field. Another, more popular view at present, is that the protons and electrons in this zone are the products of the decay of a neutron, and that the neutrons responsible are some of the products of nuclear disintegrations produced in the earth's atmosphere by cosmic ray bombardment. These conflicting views will be settled when more detailed measurements are made of the energy spectrum and life times of the various processes involved.

(*b*) The outer zone is believed to consist almost exclusively of electrons with an upper energy limit of about 100KeV. and with something like 10^{11} electrons/cm.^{2}/sec. in the heart of the zone. This zone is very variable and there is no doubt that this variability is closely linked with magnetic storms and solar eruptions. For example, it has been found that a big magnetic storm on the earth drains the electrons from this zone, and that it is repopulated in a few days presumably with electrons from the sun. Cause and effect are not yet distinguished, but it is clear that this outer radiation zone is very closely linked with the major geophysical effects observed on earth, such as magnetic storms and the aurora polaris. It seems that this zone acts in the rôle of a reservoir of charged particles with the sun as the source and the earth as the sink.

The energies of the particles in these zones are small compared with the energies of thousands of millions of electron volts with which we are accustomed to deal in cosmic rays and with accelerating machines on earth. The numbers involved, are, however, vast compared with the flux of cosmic ray particles incident on the atmosphere from space—about 2 protons and heavy nuclei/cm.^{2}/sec.; and it is this quantity rather than energy which gives the zones their special importance and, indeed, danger to living organisms. In terms of common radiation dosage, cosmic rays represent about 0·01 roentgens/hour, compared with the permissible human dosage of 0·3r/week. In the heart of the outer radiation zone the dose is about 10r/hour—5,000 times greater than a human being could stand.

The flight of Pioneer IV in March, 1959, was tracked to 650,000km. from the earth before the expiry of its batteries. Beyond 60,000km. the radiation counters reached a low level corresponding to the cosmic ray background, and although small fluctuations were present, there was no significant change over the rest of the journey.

The early experiments with earth satellites and space probes have yielded a remarkable discovery which is in process of revolutionizing our beliefs about the major geophysical phenomena. Further, they have destroyed the belief that the earth's physical environment extended only to a few hundred miles. The major influences of the earth's environment are now set at about 60,000 to 70,000km. or about 10 earth radii. It is beyond these regions that outer space can really be said to begin, in the sense that the influence of the sun, planets, stars and galaxies predominate, over the terrestrial environment.

3. THE INTERPLANETARY MEDIUM

I suppose that most of us have grown accustomed to the idea that the space between the planets is a vast region of emptiness, and indeed, as judged by terrestrial standards this view is essentially correct. However, during the last few years the scientist has been forced to realize that the simple concept of a sun, with the earth and planets moving around it and with little of interest in the intervening interplanetary space, will no longer suffice. The discovery of the radiation belts demonstrated that the earth's influence exerted a major effect on the interplanetary medium to a distance more than 100 times that assessed from earthbound investigations, and it is now a reasonable assumption that the planets too will be surrounded by similarly trapped belts of radiation. If, indeed, the major planets like Jupiter (which is 11 times the radius of the earth and 318 times more massive) has a commensurate magnetic field, then the trapped radiation around it must be very extensive. Here is a major problem for the deep space and planetary probes which will no doubt be launched in the coming years. So far all that can be said is that Lunik II, which landed on the moon on 13th September, 1959, showed that the magnetic field of the moon, if it existed, must be less than 100 gamma (or 400 times less than the field at the earth's surface), and that no surrounding radiation belts could be detected. This result is not unexpected.

In the case of the sun, our ideas about its size and influence seem to have increased steadily. It has, of course, been known for many years that the solar atmosphere, or corona, extended far beyond the normally recognized visible disc of the sun. Until the invention of the coronagraph by Lyot, the corona could be studied only during a solar eclipse, and knowledge of it accumulated slowly. The coronagraph gave astronomers the ability to study the corona at will and soon afterwards the discovery that radio waves were emitted by the sun added still further to the rapid accumulation of knowledge. When the surface of the sun is disturbed by spots and flares intense radio waves are emitted, but even in its quiet condition radio emissions from the sun can be detected. These come from the corona, and a strange result has emerged. The size of the sun depends on the wavelength used by the investigator. By eye we normally see the chromosphere, and the solar radius can be measured as about 700,000km. If a radio apparatus is used to measure the size, this comes out to be much bigger because the radio waves are emitted from the coronal regions. On a radio wavelength of 10cm. the sun is about 1.5 times bigger than the visible disc. At 3m. it is 3 times as big and on wavelengths of 8m., the corona has been estimated to extend to at least 10 solar radii.

These results have been known for some time, but apart from the intense radiation and the streams of hydrogenous material which are ejected during solar flares it was still believed that we were effectively separated in space from the sun. Now it seems that we must abandon even this degree of isolation. The physical conditions in the corona are now fairly well established out to a few solar radii. For example, at a height of half a solar radius above the visible

disc there are about 3×10^7 atoms/cc. and the effective temperature is a few million degrees. Recent calculations indicate that these conditions will result in an outward pressure which causes the material of the corona to expand outwards continually with a speed of between 500 to 1500km./sec. This streaming material, which has been called the solar wind, envelops the earth and the planets, and it seems that we live inside the shell of a disturbed field of solar plasma which extends to the outermost planets. The outer radiation belt surrounding the earth must represent the interfacial region where the magnetic field and material of this solar wind has to reach a compromise with the earth's own geophysical environment. These are new concepts, which with the radiation belts amount to a revolution in our thinking about the controlling forces in the solar system. The concept of the solar wind should soon be put to a direct experimental test by instruments which are to be carried in an American deep space probe launched inwards from the orbit of the earth towards the sun.*

This oupouring of radiation and particles from the sun is the least tangible of the contents of the interplanetary medium. The shooting stars, or meteors, which are a feature of a clear dark sky, represent the burn-up in the earth's atmosphere of particles which populate the interplanetary space. The relative infrequency of these as seen by a single observer on earth gives a false impression of their numbers. The number of meteors entering the earth's atmosphere which are big enough to produce a trail bright enough to be seen in a small telescope is about 8,000 million per day. These are very small grains of dust weighing only about a ten-thousandth of a gram. As the particles get bigger their numbers decrease. Objects which we recognize as bright fireballs probably weigh about a gram, and there may be a million entering the atmosphere per day. Altogether about 1,000kg. of meteoric material burn up in the atmosphere every day, and another 500 kg. enters in such big pieces that these do not burn up completely and fall through to the earth as meteorites.

No one is certain how these great quantities of dust originate. Two classes are commonly defined. The shower meteors move in a great assemblage, pursuing an orbit around the sun often identical with that of a comet. Regularly, every year, the earth intersects a dozen or so streams of debris in its journey around the sun and for a few nights there is a greatly enhanced rate of meteoric activity. Although to the naked eye these are the most spectacular occurrences, the greatest number of meteors move in ungrouped orbits and are known as sporadic meteors. Some years ago it was held that these meteors were pursuing hyperbolic orbits around the sun and must therefore be meteors from interstellar space. One of the first results of the application of the radio astronomical techniques to the study of these meteors was the proof that the sporadic meteors moved in short period orbits around the sun and were confined to the solar system.

During the last decade the photographic and radio echo study of meteors has led to notable steps forward in our understanding of these meteoric phenomena, and in the use of the trails which are formed in the atmosphere for the study of the physical conditions in the region of 80 to 120km. above the earth's surface.

* Pioneer V was successfully launched on 11th March, 1960.

None of these techniques can investigate the particles which are too small to burn up. These are the micrometeorites. When the radius of a particle is less than about a millimeter, the ratio of its surface area to mass is so large that the energy of interaction when it begins to enter the atmosphere is radiated away, and the flight of the particle is stopped before evaporation occurs. Eventually these pieces of dust fall to earth, and from a study of the deposits on the ocean bed it has been estimated that the earth collects something like a million tons per annum in this way.

Here is an obvious challenge to the techniques of earth satellites, and scarcely a Russian or American satellite or probe has been launched which has not contained some form of device to study these micrometeorites before their interaction with the atmosphere. In principle the experiment should be easy—for example, a sensitive microphone to record the impacts. In practice the experiment has proved difficult, since in the simple impact methods it seems likely that the microphones have recorded disturbances other than those caused by the impact of the particles and the calibration is uncertain. The results available at present indicate that both the U.S.S.R. and U.S.A. satellites and probes have recorded the impact of dust particles which weigh only 10^{-8}-10^{-9} grams and that the equivalent rate of impact over a surface of 1 sq. metre area is one every 1,000 secs. (for 10^{-8} gram particles) and one every 100 secs. (for 10^{-9} gram particles). The Russian results tend to be lower by about one order of magnitude in frequency of impact.

These results imply that the spatial density of dust of this size in interplanetary space is a thousand or ten thousand times greater than that of the dust which is big enough to burn up in the atmosphere as meteors. This conclusion is not unexpected from the trend of increase of quantity of dust with decreasing size exhibited in the results of the earthbound measurements on meteors. The refinement of these measurements in space probes and satellites, coupled with further development in the ground-based photographic and radio echo meteor work, will certainly lead to a much better understanding of the rôle of these particles in the formation and evolution of the solar system. At present it is believed that the large meteorites which fall to earth have a different origin from the meteors. Are the micrometeorites an extension of the size range of meteors or are they too, a separate class? Does all this debris represent samples of the primeval material left over from the formation of the solar system or is it the consequence of some subsequent planetary catastrophe?

4. THE MOON AND PLANETS

A good deal of purely astronomical data about the moon and the planets can be found in the text-books. The distances, masses, sizes and many other facts have been deduced from a study of the motion of the planets by normal visual and telescopic observations. There are, of course, some important gaps—Venus, for example is cloud-covered and has yielded little reliable information about its period of rotation. Also, the existing errors in the measurement of the fundamental unit of distance in astronomy—the solar parallax—means that we are uncertain

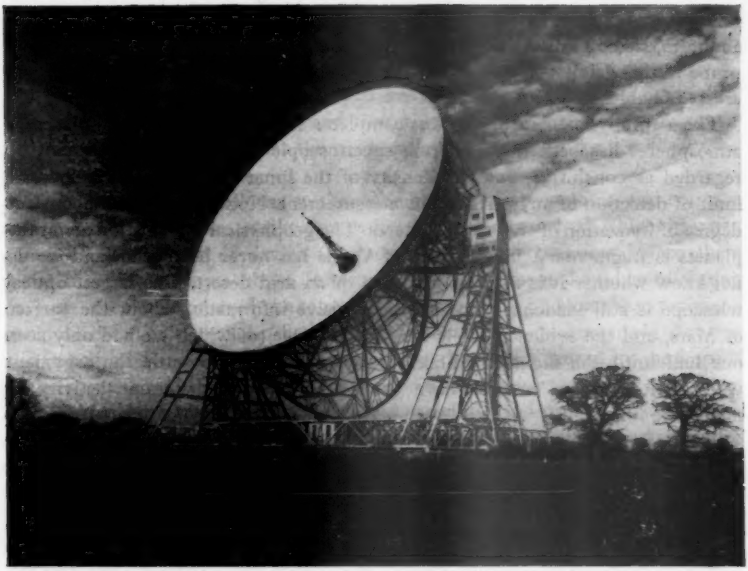
of the distance of the nearer planets to about 10,000 miles. Rather a small uncertainty in terms of the distance of a near approach of a planet to earth of about 30,000,000 miles; but quite critical when plans are made to send a space probe to the vicinity of a planet. On the whole the essentially astronomical data are reasonably complete.

The astrophysical data are far less complete. The constitution of the planetary atmospheres has been inferred from spectroscopic observations but cannot be regarded as conclusive, and the density of the lunar atmosphere is below the limit of detection of any earthbound measurement. Nothing is known about the degree of ionization of these atmospheres. The geophysical information about the planets is fragmentary. The surface of Venus has never been seen, and we do not know whether it is a complete ocean or an arid desert. The largest optical telescope is still inadequate to provide decisive information about the surface of Mars, and the evidence about the lunar surface (of which we had only seen one half until the flight of Lunik III) is insufficient to settle the argument whether its surface features have been determined by volcanic activity or meteoritic impact.

The more detailed study of the moon and the planets has for some time appeared as a vital task for all who are interested in the problem of the origin of the solar system, and in the possible existence of organic material elsewhere than on earth. The impasse which the conventional techniques had encountered has now been broken by the tools of radio astronomy and the space probe.

Radio telescopes have now measured the radio emissions from several of the planets in the region of centimetre wavelengths. This is the thermal emission appropriate to the temperature of the body, and useful comparison with the temperatures derived by optical studies are being made. More surprising is the detection of large sporadic outbursts on long wavelengths from Jupiter. The energies involved in the generation of these radio waves must be enormous. There is some evidence that the events occur on the surface of the planet rather than in its atmosphere. Should this be the case the forces at work must be equivalent to the energies involved in several hydrogen bombs, or in giant volcanic eruptions like the explosion of Krakatau.

These passive radio astronomical studies are full of interest, but the greatest dividends are coming from the use of the radar or radio echo techniques of radio astronomy when applied to the moon and the planets. After the war the further development of radar to achieve sufficient power and sensitivity in order to send a pulse of radio waves to the moon, and detect them again on earth after reflection from the lunar surface, was soon accomplished. Some people thought this was little more than a stunt, or at most a stage in the technical development of radar. However, those who pursued the problem have been rewarded by a most striking series of results. As soon as large steerable radio telescopes became available the study of the lunar radio echoes was much easier. It was found that although the pulses sent out from earth remained always of the same strength, those that returned $2\frac{1}{2}$ seconds later exhibited marked fluctuations in intensity. These fluctuations have been found to be caused by two different



The radio telescope of the University of Manchester at Jodrell Bank in Cheshire. The steel bowl is 250 ft. in diameter and the moving superstructure weighs 2,000 tons. The telescope can be used as a receiving device for the exploration of the remote parts of the universe or to track space probes, and as a radar instrument in which role it has been used to study meteors, the moon, Venus and the carrier rockets of the Sputniks. (*Crown Copyright*)

effects. First, in traversing the ionized regions surrounding the earth the plane of polarization of the radio waves is rotated. This effect has now been turned into an important new technique for measuring the total number of electrons along the line of sight between the earth and moon. Second, the libration, or movement of the lunar surface relative to the earth, causes a rapid fading in the reflected signals. The analysis of this fading revealed an unsuspected feature of the lunar reflection. It was assumed that the whole hemisphere of the moon presented to earth would take part equally in the scattering of the radio waves. This is not the case. The bulk of the scattering takes place at a portion of the forward hemispheric cap which is only about one-fifth of the depth of the lunar radius. This had an immediate practical reaction because it was realized that if the moon behaved in this way as a reflector on radio wavelengths, then it should be possible to use it as a passive relay station for the transmission of intelligible speech over long distances. The excellent clarity of speech transmitted across the Atlantic in this way has been demonstrated, and since this is a form of long-

The control room of the telescope. Computers enable the telescope to be placed under automatic control so that the motion of the earth can be counteracted in order to keep the telescope directed at any part of the sky

distance radio communication which can be carried out on wavelengths which are not susceptible to ionospheric or other terrestrial disturbances, there is probably a commercial future in these techniques.

The extension of these lunar radar experiments to the nearer planets presented a major challenge. The moon is 240,000 miles distant and the return journey of the radio waves from earth takes 2½ seconds. At close approach Venus is nearly 30,000,000 miles and the radar signal would take over 5 minutes on the journey there and back to earth. In terms of sensitivity of apparatus it is ten million times more difficult to achieve than the lunar echo. However, a beginning has been made. An American team with a transmitter of a very great power on an 80 ft. radio telescope, and a team at Jodrell Bank using a smaller transmitter on the 250 ft. radio telescope, have both achieved initial success in these Venus experiments. Even with these preliminary results a direct measurement of the distance of the planet has been made and the range of uncertainty

about the value of the solar parallax has been significantly reduced. It is hoped that in the near future further extension of this work will enable the rate of rotation of the planet to be measured. It is likely, too, that the experiments will give some guidance on the nature of the surface of the planet.

At the moment no one can be sure whether the first determination of the rotation period of Venus will come from these radio astronomical studies, or from instruments carried in a space probe which either orbits or makes a close approach to the planet. There are, however, many aspects of these lunar and planetary studies which can only be achieved by the physical presence of instruments carried in space probes. Lunik II crashed its instruments on to the lunar surface. Soon we may expect control to be exercised in the final stages of flight. Then either a soft landing can be made and the instruments maintained in working order on the lunar surface, or the probe can be placed in close orbit around the moon. Then we shall have the potential of studying the lunar atmosphere, and magnetic field (if any exists); and of making the detailed measurements on the lunar surface which may well have a decisive influence on many outstanding conflicts of opinion. The history of many aeons of time is contained on the lunar surface, which must be almost untouched by erosion. Is there, for example, an identity of material between the meteorites which crash to earth and the surface of the moon? The analysis of certain meteorites made by Urey seems to indicate that at some stage in their history they must have gone through processes of heating which could only occur in the interior of a body of lunar size; and that these meteorites which we handle to-day are the result of a shattering of these moons in collision. If this is correct there must, at some stage in the evolution of the solar system, have been at least 10 objects the size of the present moon which eventually disintegrated in mutual collisions. It seems that these lunar investigations may well hold the key to a major problem in the evolution of the solar system.

5. THE SEARCH FOR EXTRA-TERRESTRIAL LIFE

Discussions of the possible existence of intelligent life on other planets in the solar system has for long been the domain of speculative writers. Little serious attention has been given to this by scientists, first because there seemed no reasonable prospect of carrying out any decisive investigations, and second because the ideas about the mode of formation of the solar system led to a belief that it might be a unique process. The situation has changed with dramatic suddenness. To begin with, the idea that the earth and planets were torn from the sun by a passing star in an encounter which must be an extremely rare event in the universe, has been abandoned. Now we believe that the earth and planets were formed by the accretion of large numbers of small solid particles from a dust cloud which was either formed with the sun or which the sun collected at some stage in its journey through interstellar space. This process must be a common occurrence in the universe. Moreover on the old view, the existence of even the most primitive forms of organic material would have been impossible until a rather late stage in the evolution of the solar system when the outer layers

of the earth had cooled. On the accretion theory there is no reason why the pre-life processes should not have existed on the primeval dust and been preserved during the accretion phase. The question of the existence of organic material, and indeed of living organisms, in other parts of the solar system and the universe is therefore removed from the astronomical to the biological domain.

The planets Mars and Venus are crucial in respect of any biological investigation. Their physical conditions and environment would not seem to be necessarily prejudicial to some forms of biological development, and indeed the presence of plant life on Mars is strongly suspected from recent spectroscopic studies. Instrumented probes will soon approach these planets—indeed the American probe intended to be placed in orbit around Venus was postponed in June, 1959, because of time scale difficulties only and not because of lack of capability. There are at least two crucial biological experiments now under development which will be carried in these future probes. One is an infra-red spectrometer sensitive in the region of a few microns. If this instrument can be placed even within a few tens of thousands of miles of the planets it will be able to investigate the spectral regions where molecules of biological origin have very definite characteristics. The other is a microscope with an automatic collecting device which will feed it with samples of the planetary atmosphere (or surface, when a soft landing can be made). It will, of course, be associated with a device for transmitting the information back to earth, but this should not be a major difficulty—the instruments in Lunik III have already accomplished a somewhat similar task in the transmission of the lunar photographs.

Unexpected encouragement to proceed with these ventures has come during the last few months from a remarkable analysis of the organic material of a meteorite made by Calvin and Vaughn of California. By a refined spectra analysis they conclude that molecules are present similar to cytosine, one of the bases which is part of the structure of nucleic acid. This seems to be a fairly definite indication of the existence of prebiotic material on a body from outer space.

It is sometimes difficult to comprehend the excitement and gravity of the excursion of deep space probes to the nearer planets which will soon be launched by the American and Russian scientists. No human being can fail to be elevated by the thought that we are privileged to live in this age which has achieved the potential to investigate the existence of extra-terrestrial life. On the other hand, this privilege carries with it a most grave responsibility. Unless the utmost care is exercised these space vehicles may well contaminate the planets and their atmospheres with macromolecules which have developed on earth. The intentional or accidental excursion of a probe into the environment of Mars or Venus before the biological instruments are ready, might destroy for ever the validity of the biological investigations, and might, indeed, divert or destroy the evolutionary processes already at work in these domains. Two Great Powers are on the verge of these experiments, and it is the scientific and moral duty of all concerned to see that no aspects of chauvinism lead to this disaster.

6. THE COSMOLOGICAL PROBLEM

Although there is occasionally talk of probes moving with velocities near that of light, it is difficult for a working astronomer to arouse much enthusiasm for such futuristic devices as a useful astronomical tool in the foreseeable future. Even if such velocities could be achieved, the dimensions of the present observable universe are so great that the probe would travel for 100,000 years before leaving even our Milky Way system of stars. Any reasonable assessment of present circumstances leads to the conclusion that we must be satisfied with the developments of our optical and radio telescopes for the future exploration of the stars and galaxies which comprise the universe—although indeed the future ability to erect such instruments on satellites outside the atmosphere, or even on the moon, will certainly represent an important advance. Furthermore, this conservative view need cause no dismay, because the advance of radio astronomical telescopes during the last decade has engendered an optimistic outlook for the future investigations from earth of the remote depths of space.

The investigations with the large optical telescopes during the last few decades have revealed the immensity of the problem facing the cosmologist. Any egocentric view which human beings might have about their place in the cosmos has been finally dispelled. The sun and the solar system is in one of the spiral arms of a galaxy containing ten thousand million stars. The hub of this system, which is commonly known as the Milky Way, is 30 light years distant from the sun, and the entire system extends for 100,000 light years in space. Many of the diffuse nebulæ which Herschel thought might be external to this system have proved to be so. The nearest of these great extragalactic star systems is the famous spiral nebula, M31, in Andromeda, similar in size and content of stars to the Milky Way but lying at a distance of 2,000,000 years from us. Beyond, the telescopes reveal a universe throughout which billions of these galaxies of stars are scattered out to the greatest distance of penetration yet achieved by the optical telescopes, two thousand million light years. The telescopes view these distant galaxies not as they exist now, but as they were when the light started on its journey through space two thousand million years ago.

These galaxies exist in great groups or clusters, and as far as we can see the overall large-scale structure of the universe exhibits a high degree of uniformity. Within the clusters the galaxies are in motion under their mutual gravitational attraction—for example, the Milky Way system and the Andromeda nebula, which are the chief members of the local cluster, are moving towards one another at a speed of 120km./sec. On the other hand, the clusters as a whole exhibit a recessional movement—the expansion of the universe. The speed of recession increases linearly with distance out to the present observational limit of two thousand million light years, where it amounts to 60,000km./sec. or one-fifth of the velocity of light.

If we retrace the past history of the universe, then as we recede into history we might expect to find that all the clusters of galaxies and the entire material of the universe would contract into smaller and smaller regions until at a time of

about ten thousand million years ago, the primeval material of the cosmos was concentrated into a very small volume. Does this, in fact, represent the moment of creation of the universe, or are we wrong in our interpretation of the observations? Is there, for example, a continuous creation of material, the pressure of which causes the expansion of the universe, but all the time new galaxies of stars are in formation to replace these that recede from our field of view?

When the telescopes penetrate into space they look back into the past history of the universe; we see M31 as it was two million years ago, the remote Hydra cluster as it was 2,000 million years ago. Within this vast span of time and space there is little in the observational material to indicate either whether the uniform distribution extends to even more remote epochs, as it would do if the universe was in a state of continuous creation, or whether the spatial density of the material of the universe is increasing as it would do if the cosmos evolved from the super-dense primeval material, ten thousand million years ago. A still further penetration is needed in order to explore those depths of space which may hold the decisive answer to this problem.

7. RADIO ASTRONOMICAL STUDIES OF THE UNIVERSE

During the last few years the results with the radio telescopes have encouraged us to believe that the new techniques of radio astronomy may make a decisive contribution to this problem. The studies of the radio emission which come to us from outer space have revealed a complex situation. One of the simplest experiments in radio astronomy is to make a map of the strength of the radio waves coming from different parts of the sky. If this is done with a small aerial, or radio telescope, which receives in a broad beam, the results seem to indicate a general correlation between the strength of the signals and the density of common stars; that is, the strongest signals come from the regions near the brightest parts of the Milky Way which contain the most stars. Eventually when large radio telescopes which receive the signals in a narrow beam are used to obtain a radio map of better definition, then new features begin to protrude on this general correlation, and now we know that the radio emission from space must have various origins. At the present time I think that there would be general agreement about the following summary of the position.

(*a*) The ten thousand million stars of the milky way are distributed in a large flattened disc across which light would take 100,000 years to travel. This system also emits radio waves over a wide range of wavelengths, but although there is a background emission the strength of which follows closely the intensity of starlight, the common stars do not emit the radio waves. Apart from the sun no one has yet succeeded in detecting radio waves from any of the common bright stars such as Sirius or Capella. It is likely that this emission comes from the ionized hydrogen gas which is concentrated in the plane of the Milky Way. The galaxy contains also regions of neutral hydrogen gas, and it is from these that the spectral line on a wavelength of 21cms. is emitted. The brilliant development of the investigations of this spectral line, particularly by the astronomers in

Leiden, has displayed the detailed spiral structure of the Milky Way system in a manner which could not have been foreseen a decade ago. There are two further striking features of the radio emission from the Milky Way. First, there is a broadly distributed radio emission which extends far beyond the limits of the visible stars. This forms a galactic halo or corona, and since there is no known material in these regions it seems possible that the emission arises from the movement of high energy electrons in the galactic magnetic field. Second, there are a relatively small number of discrete or localized radio sources (radio stars) concentrated amongst the stars in the Milky Way. The strongest radio source in the sky, in Cassiopeia, has been identified as a diffuse region of filamentary gas in violent motion. Another is coincident with the supernova of AD1054 (the Crab nebula), and it seems quite possible that these Milky Way radio sources may all be the remains of supernovæ in various stages of antiquity.

(*b*) Outside the galaxy, a few dozen of the nearer and brighter extragalactic nebulæ have been identified with the radio telescopes. The Andromeda nebula is now relatively easy to study with contemporary instruments, and it is apparent that this behaves as a radio emitter in the same way as our own Milky Way, including the presence of an extended corona outside the limits defined by the visible stars. It does not seem at the moment that any instruments are sensitive enough to detect more than this small number of normal, individual extragalactic nebulæ.

(*c*) None of the sources mentioned in (*a*) or (*b*) can account for the most striking feature of any high sensitivity radio survey of the heavens, which shows several thousand localized radio sources which appear to have an isotropic distribution. We believe that these sources are extragalactic and that our failure to associate them with visible nebulæ arises because they are peculiar objects at very great distances in the cosmos. The dozen or so which, after great labour, have been associated with faint objects photographed by the 200-inch optical telescope, strengthens this belief. The most famous of these sources is in Cygnus—it is the second strongest radio source in the sky, associated with a collision of two entire galaxies of stars at a distance of 700 million light years. Some other similar cases of interaction or collision are known in which objects which are almost invisible optically produce radio emissions which can be easily recorded with contemporary radio telescopes.

The modern radio astronomical techniques have given us new and powerful methods for investigating galactic structure and a wide range of astrophysical problems. Through the avenue of physical processes which are not yet understood it seems that radio telescopes may penetrate to regions of space beyond those attainable by the optical telescopes. The imagination is stimulated by the prospect that man now has the instruments at his disposal on earth to study events which are occurring at distances of several thousand million light years; this may give us the information about the condition of the universe in those remote epochs which might settle the conflict of opinion about the evolutionary processes of the universe. Nature has never yielded her secrets easily, and the attempt to settle this question is not proving an exception. The two main groups

of radio astronomers in England, at Cambridge and Jodrell Bank, are engaged in this work. In terms of hard facts the radio telescope with which I am associated has already spent one quarter of its 10,000 hours of research time on the investigation of a single aspect of this problem. All that can be said now is that the results are encouraging, and there is nothing to undermine our belief that some, at any rate, of the unidentified sources may lie at distances of six or seven thousand million light years.

CONCLUSION

In this lecture I have chosen to speak about some aspects of the exploration of outer space because they interest me and because my daily life is wrapped up in some of the problems involved. Under these circumstances I know that it is easy to gain an exaggerated view of the importance and interest of the subject, and indeed to become too optimistic about the possibility of reaching solutions to problems which have faced man for all time. Even so, in spite of the hazards of the world to-day, it does seem that we live in a privileged epoch in which man has achieved supremacy over great technical barriers so that we are enabled to explore two issues of tremendous importance to humanity, bearing on the uniqueness of life and the origin of the universe. Occasionally, people with a mundane view of existence ask why it is necessary to do such work. In this case one can only respond in kind, and point out that nearly all the technical devices on which the cultural and economic strength of the Great Powers is based can be traced back within a few decades to fundamental scientific research supported and carried out without expectation of, or indeed, interest in, practical benefits. However, it is an innocent mind which does not see how the space probes and the radio telescopes have emerged from the cataclysm of war, and that to-day they remain close relations of the defensive devices of nations. The danger, as I see it, is not that the aspects of research which I have discussed will lack support, but that they will be supported extravagantly for the wrong purpose. The devices of the scientist who is concerned with the exploration of outer space are double-edged. It will be an inconceivable disaster if they are built up and organized in such a way that they can too readily be switched in support of national jingoism at this crucial moment of the inquiry into the fundamental nature of life and the universe.

DISCUSSION

MR. CYRUS HAYES: May I ask the speaker to enlighten us as to whether there are people on the moon?

THE LECTURER: There is no evidence of any form of human life on the moon. It is possible that the lunar dust may contain some indication of these early biological developments which I mentioned. Obviously the moon is less favourable than the planets Mars and Venus, where—from all that we know of the possibilities of the evolution of organic materials—it is not at all unlikely that such developments may have occurred. The moon is more unlikely, but it is not impossible; in some of the more protected crevices of the lunar surface investigators might find some primeval forms of life. If you ask my personal view, I do not think there is any form of intelligent life anywhere in the solar system; but this is not really the significant point: which

is to establish whether any primeval organisms which could subsequently develop have existed elsewhere in the solar system at any stage.

MR. HAYES: I asked that question because people have said that the moon is a dead world; and I took that to mean that there has been life on the moon which has fizzled out.

MR. MAURICE GOLDSMITH: As a supplement to this last question, does Professor Lovell have any opinion on the viewpoint expressed recently by the Soviet scientist Agrest that the story of the destruction of Sodom and Gomorrah is susceptible to explanation in terms of visitors from outer space?

THE LECTURER: Professor Masevitch, who has been visiting this country, was asked this question at a press conference. She answered, 'Science fiction'!

MR. G. VIVIAN DAVIES: Can our speaker give us briefly any indication of why it is, or how it is, that the Russians can pinpoint a target with such frightening accuracy?

THE LECTURER: Technically the reason is that the Russians have a last stage which contains liquid fuel, which gives them refined control from the ground. The rockets go up in three stages, and the American ones have solid fuel on the last stage, and there is no guidance—no possibility of control.

MR. J. LLOYD OWEN: In the ancient world they were much concerned about the hen-egg problem, i.e., which came first. In the modern world we are much more concerned about electricity, magnetism and gravitation—which came first—or rather which is the most fundamental. Einstein, Blackett and others have worked on this very difficult problem. I wonder if Professor Lovell could tell us whether this new information about the radiation belts round the earth is likely to throw light on this conundrum?

I personally find it difficult to understand, if Faraday's laws are obeyed, the explanation of these belts proposed by Bondi and others, viz.: that the electrons spiral round the magnetic lines of force, moving towards the poles, and then (conveniently) reverse and move towards the opposite poles. Is it conceivable (if a little fantastic) that these electrons complete the circuit through the metallic core of the earth? Does this core in some way act as an electron pump sucking in electrons at one end and ejecting them at the other?

THE LECTURER: The first question is a difficult one. The general answer is that the future investigation of the magnetic field by probes in the vicinity of the moon and planets is bound to be critical in any decision about these various theories. For example, there is doubt whether the earth's magnetism is associated with the geophysical environment of the earth or of its internal constitution, but these doubts might be settled when it is possible to measure the extent of the field around the planets like Jupiter and Mars. The only evidence at the moment is from Lunik II. The magnetic field of the moon was found to be less than 100 gamma, that is four hundred times less than the field on the surface of the earth, but this is not an unexpected result and one would have to make a soft landing of instruments on the moon's surface before this measurement could be refined. So I think that, although the measurements at the moment have not given much information about the fundamental cause of planetary magnetism, they may well do so in the next few years.

On the question of spiralling electrons—I really do not see any difficulty about that. Near the reversal point the lines of force are converging, and it can be shown that under these circumstances the inter-action between the electrons and the magnetic field is such as to create an effective reverse pressure on the motion of the electrons, so that at a certain point in the converging field their motion will be reversed.

MR. H. T. MILLS: Could Professor Lovell tell us if there is much evidence of an infall on the sun?

THE LECTURER: An infall? Well, I think of the films which have been taken at Harvard Observatory and other places of eruptions on the sun, which show great streams of hydrogenous material being shot out thousands of kilometres into space and then falling back into the solar surface. Undoubtedly a lot of the material which is ejected during explosions on the sun does fall back into the solar atmosphere again.

MR. MILLS: Then the sun does not collect particles from space?

THE LECTURER: It is rather difficult to be decisive about that. A few years ago it was believed that the solar system, and therefore the sun, collected all the sporadic meteors in their journey through space. In other words, that they had an origin in interstellar space and were not confined to the solar system. The advent of radio-astronomical measurements led to a decisive answer to that problem: that they are confined to the solar system. On the other hand, since interstellar space contains dust and hydrogen atoms, the sun and the solar system must be collecting that. Sometime in its history—if one view of the evolution of the solar system is correct—it must have run into quite a dense interstellar cloud. That is perhaps how it got its corona which eventually formed into the planets and earth.

MR. KENNETH W. GATLAND: I should like to know whether the Jodrell Bank Station is to continue experiments involving the reflection of radio signals from the moon for radio-communication purposes? It seems to me that this is a rather vital field for Britain to be in. Are we to expect that Jodrell Bank Station will continue this work (which after all, is not its real purpose) or does Professor Lovell know whether a government authority in this country will in fact take it over?

THE LECTURER: Before I answer that may I just clarify the question? Are you asking if we are going to continue the work on the moon or on co-operating with the Americans in the inflatable sphere artificial satellite communication experiments?

MR. GATLAND: I meant the development of this work now, in conjunction with inflatable satellites.

THE LECTURER: Probably not much more on the moon. We still have a few more fundamental measurements to do, and then it is largely a question of commercial development.

MR. GATLAND: For commercial purposes the moon is possibly inferior because of the scattering effect that has been demonstrated.

THE LECTURER: Well, it depends on whether you belong to a country which can launch satellites and inflatable spheres. The answer on inflatable spheres is that we have been asked by the Americans to take part in some of these experiments; we have promised to track the satellite during the first few orbits, but we have not yet decided the extent of our co-operation in the actual transatlantic communication experiments. The programme for the telescope is very full, ad it is difficult to justify experiments unless one can see any crucial research task likely to evolve from them, and that is not very easy to see in the case of the inflatable sphere. I doubt if we really have a major part to play.

MR. W. WALTER: If the evolutionary theory of the universe should eventually prove to be correct, has anybody given consideration to the possible source from which the hydrogen atom can be generated, or in what manner it can be generated?

THE LECTURER: The answer is that a great deal of thought has been given to this, by philosophers and by scientists. It is not a problem which can legitimately be asked of a scientist, because as far as he is concerned, if indeed the universe did originate in this way, this would imply the beginning of space and time as we know it, and that is largely a philosophical and theological problem. I might add, as a rider, that not all the variants of the evolutionary theories imply such an initial event, and there are

types of the evolutionary universe in which the cosmos has a cycle of existence, an alternate expansion and contraction. I was very interested to learn recently that after very tentative approaches in the cosmological field the Russians are now thinking in terms of another theory in which the process of expansion and contraction may be taking place simultaneously in different parts of the cosmos.

MR. WALTER: What I really meant was this: you gave an actual measurement of the generation of the hydrogen atom; well, if a hydrogen atom is being generated it has got to come from somewhere.

THE LECTURER: The answer is that it comes from nowhere. This is a fundamental limitation of the theory. The philosophical difficulty remains. In the evolutionary theory it occurs at a finite time in the past, and in the steady state theory the problem is with us now and for all time.

DR. W. F. HILTON (Astronautics Section, Hawker Siddeley Aviation Ltd.): I also share the lecturer's hope that we shall use space travel for peaceful purposes. But I would remind him that the actual weights dropped by Galileo in the crucial experiments on gravity were, in fact, cannon balls, and he was employed by the military to make these experiments.

I should like to ask a question concerning these two ionized belts round the earth. I wonder to what extent they will influence or perhaps hinder radio communication with earth satellites? It seems to me that we in Britain have quite a different problem from the Russians and from the Americans. The Russians and Americans have nice compact countries in which their intercommunications take place over land, and are not dependent on overseas cables and wireless, whereas we in Britain have a very far-flung Empire. I think this is a peculiarly British problem, and it is vital to know of any possible limitation to British communication satellites.

THE LECTURER: I do not think the radiation belts matter in the communications field. They are certainly a hazard to anybody who wants to get out from the earth's surface, and it is amazing how Nature has protected us. First of all with the atmosphere from the bombardment from meteors, now we find that the radiation belts stop us getting out and any other person from getting in!

I agree as to the significance of these new forms of communication for the United Kingdom, and provided the ability to launch satellites exists, I do not foresee any fundamental natural hazard which will inhibit either the passive satellite balloon system or the active repeater satellite launched into a stationary equatorial orbit.

THE CHAIRMAN: We could go on listening to Professor Lovell answering questions for a very long time. From my point of vantage here I have seen that you have all been spellbound by the wonderful things he has told us, by the wonderful new information that is coming to light from the use of this new kind of telescope.

This is the Trueman Wood Lecture, founded in honour of a very great Secretary of the Society. Trueman Wood died in 1929. Many famous men have given this lecture since it was founded—they have dealt mainly with the application of science to the needs of civilization—and when I tell you that such scientists as Sir Oliver Lodge, Lord Rutherford, Sir James Jeans and Professor Oliphant have been former lecturers in this series I think you will recognize the quality of the lectures. But I venture to think that the lecture we have heard this afternoon will take a foremost place in the annals of this Trueman Wood Lecture, and Professor Lovell will have an honoured name among these other pioneers who have spoken here. I am sure you will wish to show your appreciation of his brilliant lecture.

The vote of thanks to the Lecturer was carried with acclamation, and the meeting then e ıded.

SCIENTIFIC METHODS IN THE CARE OF WORKS OF ART

A paper by

F. I. G. RAWLINS, C.B.E., M.Sc., F.Inst.P.,

Deputy Keeper and Scientific Adviser, The National Gallery, read to the Society on Wednesday, 2nd March, 1960, with Sir Alec Martin, K.B.E., Chairman of the Trustees of the Wallace Collection, in the Chair

THE CHAIRMAN: Mr. Rawlins wants little introduction here; he has already given a series of lectures in this Hall. He has rendered distinguished services to the care of works of art. He has been Scientific Adviser to the Trustees of the National Gallery since 1934. He became a Deputy Keeper in 1948. He is Vice-President of the General International Institute for Conservation of Historic and Artistic Works, and was a force in its foundation.

The following paper was then read:

THE PAPER

1. THE NATURE OF THE PROBLEM

It is, as it happens, twenty-three years, almost to the day, since the pleasure was mine of delivering the Cantor lectures[1] in this room, entitled 'The Physics and Chemistry of Paintings'. Now, finding myself once more concerned with a similar theme, it seems reasonable to regard the present occasion as an opportunity to report progress, and to see where we stand after the lapse of not far off a quarter of a century. Expansion of our concepts, and the surveying of 'fresh woods and pastures new' account for the use of a rather wider title than that of 1937. But two facts stand out, which cannot be overlooked, and which condition much of our thought and action to-day. The first is that we and our treasures—for better or for worse—have been through World War II: the second is that, odd as it may seem, international co-operation and the sharing of knowledge in the museum and gallery world have substantially improved since 1945. I shall have something to say later on concerning the former of those events. As regards the latter, the increasing influence of the International Council of Museums (I.C.O.M.), and the establishment of the Commission for the Care of Paintings, together with the Laboratories Committee, are notable developments. More specifically, the foundation of the International Institute for the Conservation of Historic and Artistic Works (set up within the framework of English law, under a slightly different name, in 1950) is a milestone in the recognition of the place of conservation and restoration as an occupation of high professional standing. The first conference of this body, planned for September,

1961, in Rome, is a reminder of its growing stature. Also, the presence of the new 'Centre' in the Eternal City adds something of great promise.

With so much to relate, it can scarcely be expected that the present lecture will be more than a sketch. Even so it needs casting in a slightly more contemporary mould. This means a discussion of chemical physics, rather than of physics *and* chemistry. Such a change is not a mere quibble; it denotes something fundamental, which is briefly this. For our purpose, there is no conjunction ('and'); the two sciences are one, but with the proviso that the kind of physics which we need should have a decidedly chemical slant, which is not at all the same thing as 'physical chemistry', with the parts of speech interchanged. Historically, we are in the debt of the United States for perceiving this distinction, though we may have acted upon it for our own purposes more vigorously in London than elsewhere. But why should we bother about it? Because it so happens that paintings particularly (and many other objects in varying degrees) are made up of colloids, that intermediate state of matter, larger than molecular, but smaller than 'life-size'. The fundamental equations of state of such systems, and their conditions of equilibrium, are best described in terms of chemical physics, which can deal naturally and without distortion with such concepts as thermodynamic potential and surface-energy. These are factors of importance when solvents are applied to specific areas, as in cleaning, and when large expanses of precious material are open to the atmosphere. I make no apology for drawing your attention to these basic considerations; confidence in curatorial responsibility of whatever kind depends in the last resort upon being sure that in the present state of knowledge (rudimentary as it may be) problems are not being tackled merely *ad hoc*—each one to be solved more or less, and then forgotten—but are aways being subjected to methodological scrutiny, with a view to a deeper understanding. Imagine a great classical picture, for example, exhibited upon the walls of a public gallery. The wooden panel upon which it is painted is a near-colloid (of roughly orthorhombic symmetry), the ground, paint and surface layers are all of a colloidal nature, whereas finally—and unluckily—it usually hangs in a colloidal atmosphere of aerosols, droplets and finely divided smokes. Clearly then, the colloidal state is a fact to be reckoned with, and its continuous study by the application of the principles of chemical physics will not only be rewarding, but essential. So much then for the epistemological character of the 'new look' in conservation.

There is, I believe, no doubt that just as the coercive circumstances of war hasten the application of science in the sphere of defence, so the paramount need to safeguard our national patrimony was directly responsible for major developments in thermodynamic technique in the planning of acceptable repositories during the period of armed conflict. In fact, a scheme for air-conditioning part of the National Gallery was afoot in 1938, but was cast aside in view of the heavy armaments programme in train at that time. As events proved, this was just as well, since equipment was then in a comparatively primitive state, and experience of the needs of a great collection of pictures was lacking. War-time exile was to provide both the urge and, in principle at least, the solution.

Wartime picture store inside Manod Quarry

As is by now common knowledge, a partly disused slate quarry in the Snowdon range of North Wales[2] provided adequate cover beneath which to erect a series of chambers which could themselves be air-conditioned, and which were of sufficient size to house some 2,000 pictures. Such an undertaking was carried through by the Ministry of Works, and provided safe storage, with every facility for inspection and care, until the collection could return home at the end of 1945.

The basic engineering features of this enterprise[3], though simple, are illustrative of what can be done in rather intractable conditions. We were provided, so to speak, with a vast underground reservoir of air at a nearly constant temperature of 46°F., and of relative humidity approaching saturation. This meant that, if a series of buildings of fairly flimsy construction, but reasonably well insulated, was erected, it should be possible to maintain in them, by temperature-heating alone (all the year round), a relative humidity of around 58 per cent at a temperature of about 63°F. These were acceptable figures, realized with only minor interruptions for some five years. It was of course necessary to bring refrigerating plant upon the scene to dry out the buildings when completed, but beyond that, theory was justified, and heater-batteries

plus fans, with a straightforward plenum system, did all that was needed. A remarkably efficient second-hand Diesel unit was found in Kent, and transported to the Welsh mountains to act as a stand-by plant if power from the grid should fail. Right well it performed its task.

By the time that the children of the dispersion returned to Trafalgar Square much had been learnt, the hard way perhaps, but none the less thoroughly. It was manifest that full air-conditioning, air-washing and filtration were not only worth while, but essential if a great national collection was to be preserved and seen as its value demands. As visitors know, it is becoming increasingly possible to do away with the picture glasses, which are so vexatious by reason of the reflections which they cause. Furthermore, the galleries remain clear and pleasant on days of 'smog'.

These benefits started with the experimental treatment of Room XXIX, and are extending rapidly.

In this country, the question of atmospheric pollution is very much alive, and precious material will obviously have a better chance of survival as smokeless zones become more general in our great cities and industrial areas. Recent tests have demonstrated that the water-sprays commonly incorporated as humidifiers into conventional air-conditioning units do in fact remove much of the sulphur dioxides present in the air of urban surroundings. Other parts of the world, however, have very different physical conditions to face, e.g., extreme humidity, or exeptional degrees of solar radiation. It is some comfort to know that the International Laboratories Committee, to which reference has already been made, has this problem under constant review, working in close collaboration with meteorological experts in the districts concerned. The climatology of works of art is assuredly a live subject.

The recognition of chemical physics as a deliberate discipline leads inevitably to the question as to how we propose to train people for the much enhanced duties which are beginning to unfold. I have already referred to the bodies corporate which are concerning themselves with these matters. What happens may well prove decisive before long for the whole future of scientific conservation the world over. But they are none of them in themselves teaching institutions, and the necessary amount of instruction must be done somewhere. In this I am speaking purely as a scientist, and make no attempt to assess the needs of eye and hand so essential to the restorer. Fortunately, we have in the Courtauld Institute of the University of London a laboratory building of an enviable reputation for competence and skill in the necessary techniques taught, as they should be, in close connection with art-historical studies. Further, there are the examinations of the Museums Association, to encourage people to qualify for responsible positions. Again, almost for the first time, specific plans for training in the treatment of wall-paintings[4] (a vast subject in itself) and in the care of monuments are in the process of formation. All the same, it is of course only too true that we learnt by practice perhaps better than by any other way; nevertheless, this pragmatic approach has obvious dangers, and is not the whole answer to the dilemma any more than it is, say, in engineering or medicine.

A certain substratum of fundamental knowledge, independent of immediate needs, must be provided.

Before leaving these meditations for a discussion of current events, I would refer briefly to the ever-rising standards which present-day views on conservation are imposing upon us. At the National Gallery we have tried to realize this by taking a leaf out of the book of enlightened industrial policy This amounts, as is well appreciated, to setting up a small team of people to investigate basic questions, and letting them work wholly untrammelled by the daily round and common task of routine operations; in fact, to introduce research scholars following long-term projects offering no immediate returns. By the generosity of the Nuffield Foundation this has in fact taken place at the National Gallery, a development unique, I believe, in its way. To make the picture complete, one of our scholars has been awarded a higher degree on a thesis composed in the Gallery's scientific department.

To close this introduction, it may be well to stress that the emphasis hence-forward will be on method. Examples of applications will naturally follow; they illustrate method in action rather than a series of case-records in which certain treatments have been given. In all these activities most of the work has been done by friends and colleagues over the years, and this is perhaps the place to express my obligations and indebtedness to them for their part in our progress. As a subject advances, so, luckily, does the strength of the army increase, advantageously deployed, we hope, to push out new salients into the unknown. But new conquests are unlikely to be won until priorities are at least provisionally settled. That process has been going on steadily since the war, and it seems likely that the whole movement is better focused than it used to be. At the same time, one should note perhaps a marked extension of terrain, and that is to the care of precious things which are not in museums and galleries, and probably never will be. These are objects like wall-paintings in churches and castles, ceilings, screens (both choir and parclose), monuments, decorated stone-work, and so on. Chemical physics may be hard put to it to cope with all this, but it keeps moving. One administrative problem, of fairly infrequent occurrence, is what to do with historically valuable material which has been found out-of-doors, and likely to deteriorate by weathering. If circumstances allow, as in the case of part of the Roman wall material in Northumberland, it can be assembled and placed under cover in a small museum provided for it, all well and good. Sometimes, however, it may be necessary to protect it *in situ* by means of some appropriate light-weight construction, or even to cover it up, if not of sufficient interest for permanent exhibition. But whatever decision is taken, it should be possible to obtain trustworthy photographs (perhaps in colour), so that records are available for the use of future investigators.

2. SOME RECENT ADVANCES IN METHOD

(i) *Soft X-rays*

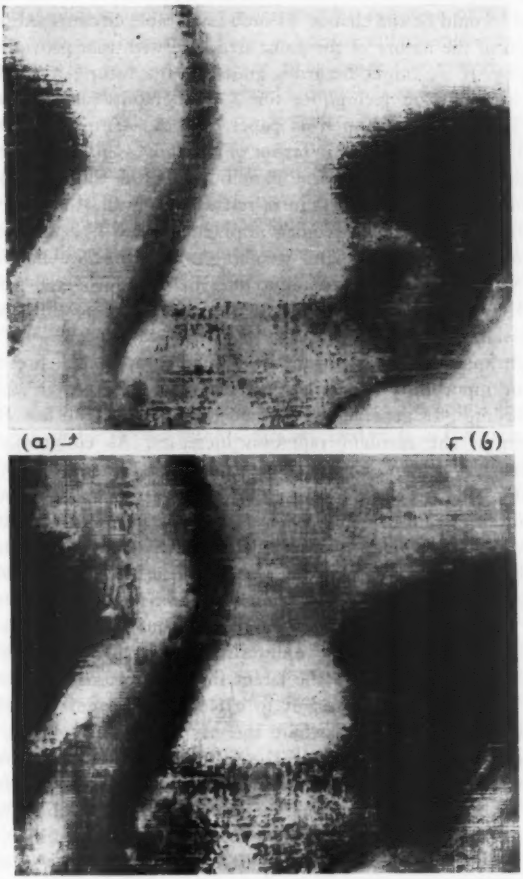
It has long been appreciated that contrast, so vital in X-radiography, is largely dependent upon penetration, so that when the material under test is relatively

'transparent', soft radiation is needed for good results[6]. This is the state of affairs for most easel paintings; metal objects and such like naturally do not need special equipment from this point of view, and to that extent are easier to examine. But where a painting shows areas wherein there has been marked abrasion, or for any reason the paint-film is exceptionally thin, then soft X-rays will be strongly indicated. (By 'soft' is meant the emission from an X-ray tube provided with a beryllium window, and functioning at around 10 Kilovolts instead of perhaps 30 Kilovolts or more in a normal tube.) The improvement is substantial, even when compared with the relatively low potential of 20 Kilovolts commonly in use. Satisfactory results can also be obtained in this way from prints and drawings, otherwise bad subjects for radiography.

In the period under review, attempts have been made (still bearing in mind the desirability of using the softest radiation available) to make use of the principle of image-amplification by means of an Electron tube, so that fluorescence pictures of high intensity can be viewed in daylight. After a good deal of preliminary work, the project was abandoned, since the increased intensity, though considerable, was not sufficient to justify so much complexity of machinery. Some success has been achieved in hospital practice by this method, but there the available contrast is usually much stronger, even at far higher potentials.

A difficulty always present with X-rays in a picture laboratory is the blurring of the image by much unwanted detail arising from the presence of cradles, struts, keys, and other externals relating to the support. If, however, the painting is on canvas, having cross-members of wood at the back (which is often the case) then obviously the X-ray film, suitably secured, can be slipped in between the canvas and the battens, and the surface of the painting arranged to face the X-ray tube. A certain degree of care is needed to obtain correct positioning, but with due precautions this is a complete answer to the problem—with panels, however, more desperate methods may be needed. One is to allow the picture to rotate, or the X-ray tube to swing through a suitable arc during exposure, the so-called tomographic principle. This has the effect of throwing out of focus any plane or planes in the structure which it is desired to eliminate, with consequent improvement in the image of the ground and paint-films. Owing to the very thin nature of the strata, the outcome is not entirely satisfactory: it may be doubted whether the difficulties involved (plus the element of risk) are really worth it. When contemplating schemes of this kind, numerical factors should be most carefully reviewed, otherwise endless trouble is likely to follow. For example, in a reasonable geometrical array (e.g., space for the tube to swing, position of subject and camera), good results can be claimed for thicknesses occurring in human anatomy and in metallography (e.g., ingots), but scarcely for pictures.

Another way, in many respects preferable, is to make use of the fact that the impact of X-rays of high penetrating power (about 200 Kilovolts) causes the emission of electrons from the heavier elements, increasing with the atomic number. Luckily lead, zinc, chromium, mercury are commonly present in our objects, and their electron emission will affect a photographic plate in contact



X-radiograph detail of a picture by Degas (National Gallery No. 3860) showing the use of soft X-rays in the examination of thinly painted or abraded pictures:
(a) *X-radiograph, 10 ma. at 7·5 K.V. showing considerable detail in the face on the right compared with Figure* (b);
(b) *X-radiograph, 12 ma. at 20 K.V. (the voltage normally used for pictures of standard paint thickness)*

with the pigments[6]. The technique is not altogether simple (and the cost of the high-voltage equipment is by no means negligible), but the results are most encouraging. It is, of course, conceivable that for a paint-layer very transparent

to X-rays, data might be recorded from the layer below. If this should prove to be so, there would be the chance, in such favourable circumstances, of the direct comparison of the nature of the paint structure with that provided by infra-red photography. If we might hazard a guess for the future, it would be that the orthodox transmission techniques for X-radiography (except the very softest radiation in special cases such as paper, tissues, stamps, botanical specimens and so on) will decline in value in favour of what are essentially reflection methods. Another point must also be borne in mind, which is this. If a lead priming is present, only electron emission or infra-red is of any avail. Although not absolutely so in theory, tomography becomes impracticable with heavy panels perhaps 3 inches or so in thickness, and weighing something like half a ton. At the moment, X-radiography has nothing to offer in the case of wall-paintings, unless of course they are treated by transfer, when it might be possible to subject them to the emission method. But this is for the future to decide.

Although applicable to all branches of photography, the present discussion provides an opportunity to mention the use of Xerography in connection with X-ray recording[7]. In general, the method becomes less and less effective as the wave-length of the incident radiation increases. As commonly understood, the film-image is a photo-chemical effect. There is, however, a purely physical photography, the so-called Xerography, which depends upon the photo-conductivity of certain insulators, more especially selenium. The basic principle is not new, but the refinements are fairly modern. When amorphous selenium is deposited upon a rigid plate of some electrical conductor like duralumin, it is an insulator in the dark, but conducts when irradiated. So, if such a coated surface is exposed to a corona discharge (at about + 15,000 volts) it acquires a surface charge, and begins to conduct if X-rays fall upon it, thus producing an electrostatic image, akin to the latent image of ordinary photography. One 'develops' the plate by exposing it to a cloud of powder particles of similar sign. Thus, the powder sticks where there is no residual charge, and forms a visible image. The process is not to be recommended for quantitative records, because the selenium particles shift ever so slightly under the impact of the radiation, but the local contrast may be high, which is valuable. Certain advantages are obtained. For example, no dark room, nor chemicals, are needed. The same plate can be used over and over again, and if one is impatient, the result can be seen in a couple of minutes or less after exposure. There is a fair amount of necessary apparatus involved. As usual, Xerography should be considered as complementary to and not as a substitute for, traditional laboratory techniques.

(ii) *Infra-red Photography*

The favourable features of infra-red photography in the arts have already received passing attention. It may now be of interest to discuss these more fully. Although there is little new to say, it is surprising how meagre is the general knowledge concerning the basic properties of objects if this 'tool' is to succeed. As a rule, we wish to obtain an image of what lies beneath some outer surface,

say discoloured varnish, or a patina, perhaps even layers of dirt. Now most of these superficial phases are readily penetrated by radiation of wave-length up to about 0·8μ (the approximate limited of photographic emulsions). That part is not difficult. The criterion, however, is whether the underlying layer has a reflectivity high enough to overpower the double (i.e., to and fro) absorption in the outer layer. If so, a positive result will occur. In point of fact, yellow, oranges, reds, and even some whites, have coefficients of reflections which increase towards the long wave-length end of the visible spectrum, and may therefore be expected to respond. Conversely, success would suggest that the underlayer or layers contain pigments of one or more of these colours. In recent years, photo-electric cells have been devised which are sensitive to these frequencies, and enable one to 'see' well beyond the red end of the visible spectrum. But it must be recollected that the energy-content is low, and high-intensity sources of radiation are therefore needed.

(iii) *Cross-sectioning*

In the Cantor lectures of 1937, the making of cross-sections from paintings for examination under the microscope was referred to as in the nature of a pious hope. It is true that the process was by no means unknown at the time, and had in fact proved to be of at least potential value. But it suffered from two rather discouraging features—firstly that the actual operation of removal of a minute fragment was decidedly clumsy (though not seriously disfiguring), and secondly, that the tiny sample, when obtained, had to be mounted in a substance which was mechanically and optically unsatisfactory. The result therefore was scarcely worth the possible risks. With the advent, however, of cold setting polyester resins, matters are considerably better, and the method is widely applied in many centres of conservation. In fact, an extensive literature exists, dealing with this technique and its limitations[8]. There is nothing novel here: nearly half a century ago attempts were being made. What is important now is to realize that mastery of this kind of problem is a pre-condition for the advance of knowledge. It is, however, necessary to assess progress as broadly as may be. For example, X-radiography covers really large areas. Microscopy includes a very minute portion. Ordinary surface micrographs and macrographs should go hand in hand with cross-sectioning if the full benefit from these analytical devices is to be secured. It is all too obvious, once this is pointed out. Nobody in his senses would dream of conducting a geological survey in a strange land by taking sections from a defile or a cutting without relating them to the visible countryside. To-day, aerial photographs would come in as well, to relate surface properties to properties in depth. Our basic principle is the same.

Of course the method has its limitations. An obvious criticism is that one is sampling such a minute area that it may be far from characteristic of anything but itself. The only reply to this is the test of experience, coupled with the evidence increasing as the number of specimens grows from all over the world. No doubt there is a statistical risk here, but we seem to have been led astray very seldom. It should also be remembered that many laboratories now possess

a collection of 'guinea-pigs' in the form of historically authenticated but aesthetically valueless pictures upon which to make experiments without let or hindrance. Many supporting data have often emerged in this way.

Here perhaps is the place to introduce a word or two about models, or better, comparative methods. Manifestly all laboratories of the kind we have in mind are subject to severe limitations in dealing with original material. Thus, some sort of 'similitude' is an ever-present necessity. Examples are pigments and fabrics exposed for fading tests in ultra-violet light, varnishes on glass slips subjected to all sorts of conditions to demonstrate their special properties. Some years ago, we put a set of trial panels through cycles of extreme conditions of heat and cold, accompanied by rapid changes of relative humidity in the Ministry of Supply Chambers of Swynnerton (Staffs.). All this is part and parcel of comprehensive planning to relate picture-mechanics 'in the raw' to the sophistication of the laboratory. It all takes time, and little can be done to hurry things along. But objects of value are presumably where they are 'for keeps', and long views are not only proper but essential. So far as cross-sections are concerned, as their numbers grow, a new sub-science of micro-stylistics is gradually evolving as a natural outcome.

(iv) *Chromatography*

This name is given to a method of analysis, which originally had applications to mixtures of colour compounds, and was, several decades ago, in particular use by botanists. In recent years, tremendous strides have been made, and chromatography has found its niche in chemical physics. For museum and gallery work it is a close ally of cross-sectioning, which is why it is convenient to discuss it now. Two points emerge. One is the proximate constitution of the natural resins[9], and the other is an inquiry into the nature of paint media[10]. ('Media' in general means the phases in which ground or powdered pigment particles are distributed to form paint. The pigment-medium complex is liquid on application, and dries to a solid film.) The importance of these two investigations scarcely needs stressing: dammar and mastic are favourite surface-coatings for a variety of reasons, whilst the identification of media—much more difficult than that of pigments—is of great moment to art historians and has hitherto made relatively little progress. With the coming of paper-chromatography, however, something of a new era may be discerned.

Suppose that we have a mixture of compounds in 'solution' (of slightly deficient chemical constitution), and that this is spotted on to the top of a strip of paper (at the National Gallery we use Whatman No. 1, specially prepared). Solvent seeps gradually downwards, and each component descends with the solvent at a characteristic rate, the distances traversed being measured from the origin. The strip of paper upon which this happens is the chromatogram. It should be noticed that to-day the name is something of an anachronism, since we are no longer restricted to coloured substances. After development colourless components of the mixture can be caused to register as coloured spots, in the appropriate positions, by treatment of the strip with specific reagents.

Photograph showing a detail of a picture varnished at the same time with alternate bands of polyvinyl acetate and mastic, one week after varnishing. The mastic bands appear lighter because of bloom

There is a rapidly mounting literature on this subject, to which those interested may be referred. This is merely an introduction to a wide field of immense promise.

(v) *New Varnishes*

The outstanding problem of a laboratory in a picture gallery is to find the perfect varnish, both from the point of view of the beholder and that of the

restorer. Such a paragon is probably incapable of existence, but much activity is to be recorded, both here[11] and abroad. Clearly, to be a serious 'candidate', a varnish must be capable of being applied with full control, and without danger to the picture, e.g., by causing swelling of the paint-film below, and perhaps new retouchings. It must also be stable over long periods of time. (The traditional dammar and mastic show substantial deterioration after about fifty years.) Long-chain linear polymers offer certain attractions, but it is essential to realize that cross-linking of the chains to form an insoluble network is a serious hazard, which has actually occurred with some of the methacrylates. If in time to come, removal should become necessary, the operation would certainly be dangerous. It is too early to enter into fuller details now, with so much research in progress. Suffice it to say that the long-term changes in paintings remain the basic problem in restoration.

(vi) *Diffusion through Films*

We have touched briefly already upon the characteristics of paint and varnish films in so far as they are vital in the fine arts. It is now advisable to consider in outline an old question in a new form, namely the action of solvents on paints and varnishes, since this is in principle fundamental to the operation of cleaning, not only pictures, but of many other objects as well. Evidently, this is a most complicated matter involving time of application, rate of evaporation of solvent, strength, and even the atmospheric environment in which the work is done. But the whole operation is, or should be, a lesson in chemical physics. Three particular aspects have received recent study. These are (*a*) the process of diffusion of solvents into varnish, (*b*) the solvent power of mixed liquids, and (*c*) the mechanical properties of swollen varnishes. As regards (*a*) an optical method in which the penetrant liquid causes a distortion of the Fizeau fringes of a varnish film clamped between half-rhodiumized plates has demonstrated some of the phenomena of the diffusion process. What happens with mixed liquids (*b*) is illustrated by our tests which show that mixtures of organic liquids may have a swelling power far greater than either of them used alone. For example, a 60/40 mixture of turpentine and ethyl alcohol will eventually cause a linoxyn film to swell to some three times the extent caused by alcohol alone (linoxyn, in brief, is oxydized linseed oil). An example of (*c*) would be a decidedly brittle specimen of oil varnish, treated by soaking in a 4/1 mixture of dinonyl adipate and benzene. In this case, an advance of some two hundredfold in plasticity was achieved.

3. CONCLUSION

The present state of affairs in the care of works of art by scientific methods is an intriguing one. It is too early perhaps to assert that the laboratory has yet exerted any definite influence upon most of the classical methods of the studio. Nevertheless, here and overseas, light is beginning to be shed upon our limited knowledge of what conditions are essential for the continued well-being of precious material, combining the widest possible range of objects, both indoors

and out-of-doors. In this, I believe that a deeper appreciation of the principles of chemical physics may hold the key to further conquests in the fields of conservation and restoration.

It is still our desire, where applicable, 'to repair the waste cities, the desolations of many generations', with all the sympathy, humility and skill which we can command.

REFERENCES (Papers)

(1) Rawlins, F. I. G., 'The Physics and Chemistry of Paintings': (Cantor Lectures) : *Journal of the Royal Society of Arts*, LXXXV, pp. 933–71, 1937.
(2) Davies, M., 'The War Time Storage in Wales of Pictures from the National Gallery, London. (1) The Course of Events' : *Trans. Honorable Society Cymmrodorion*, 1946.
(3) Rawlins, Ian, '(2) Some Technical Problems' : ibid.
(4) Central Council for Care of Churches, 'The Conservation of English Wall-Paintings. A report', 1959.
(5) Rawlins, F. I. G., 'Soft X-rays in the Examination of Paintings': *Studies in Conservation* I, No. 3, pp. 131–4, April, 1954.
(6) Bridgman, C. F., Keck, S., and Sherwood, H. F., 'The Radiography of Panel Paintings by Electron Emission': ibid., III, No. 4, pp. 175–82, Oct. 1958.
(7) Stanford, R. W., and Moore, R. D., 'Xerography with special reference to Xeroradiography': *Medical and Biological Illustration*, VI, No. 2, p. 86, April, 1956.
(8) Plesters, J., 'Cross-sections and Chemical Analyses of Paint Samples': *Studies in Conservation*, II, No. 3, pp. 110–57, April, 1956.
(9) Mills, J. S., and Werner, A. E. A., 'The Chemistry of Dammar Resins': *Journal of the Chemical Society*, Sept., 1955, pp. 3132–40.
(10) Hey, M., 'An Analysis of Paint Media by Paper Chromatography': *Studies in Conservation*, III, No. 4, pp. 183–93, April, 1958.
(11) Thomson, G., 'Some Picture Varnishes': ibid., III, No. 2, pp. 64–79, Oct., 1957.
(12) Graham, Ian, 'The Effect of Solvents upon Linoxyn Films': *Journal of the Oil and Colour Chemists' Association*, XXXVI, pp. 500–6, Sept., 1953.

ADDITIONAL WORKS OF REFERENCE

Constable, W. G., *The Painter's Workshop*. Oxford University Press, 1954.
Feller, R. L., Stolow, N., and Jones, E. H., *On Picture Varnishes and Their Solvents*. Intermuseum Conservation Association, Oberlin, Ohio, 1959.
Plenderleith, H. J., *The Conservation of Antiquities and Works of Art*. Oxford University Press, 1956.
Rawlins, Ian, *Aesthetics and the Gestalt*. Nelson, 1954.
Stout, G. L., *The Care of Pictures*. Columbia University Press, 1948.

THE CHAIRMAN: Mr. Rawlins has given us a lot to think about. The qualifications of a scientist can partly be measured by the extent of his academic degrees, those of a Curator or Director by his experience; and the same may be said about the restorer, good or bad. In my long experience of bringing pictures from country houses to Christie's for sale, I have often heard it remarked that they were in wonderful condition. Many of them had not been touched for many years, and some not touched since they were painted. And then within a very short time after I have sold them I have seen many of these pictures in dealers' shops, over-cleaned, over-varnished, their frames polished up as bright as possible, their virgin quality gone. I am therefore very glad that the Government has taken an interest in these matters and is going to devote more money to the pursuit of their study. At the Wallace Collection, where we are very proud of our possessions, we do very little restoring and then only when absolutely necessary. About glasses on pictures: we did some time ago experiment in taking the glasses off two or three of our pictures, but we had to put the glasses back very soon afterwards for their own protection, because the paintings were being maltreated by visitors.

May I tell you of an experience of my own? When I was a small boy, just after

I went to Christie's, my mother thought that I should get to know something about pictures, so she went into a shop, in the Brompton Road, packed with pictures, drawings, books and everything else, where Ricketts and Shannon used to buy their own master drawings for prices like 5*s*., 7*s*. 6*d*. and 10*s*. each, and she bought a picture on panel for 30*s*.—she certainly could not afford any more. It was black with dirt. She brought it home and said to me, 'You try and clean that!'. I got a basin of hot water and a bar of Sunlight soap and I started on the picture. Just then came a knock at the front door, and up I went to answer it. I stood at the door for some minutes. When I got back I found that I had left the bar of soap on the panel of the picture, and in lifting it up I lifted all the paint underneath the soap. My mother took the picture away from me and handed it to a qualified restorer. It was seen by Mr. Ernest Leggatt, the then head of Leggatts. When it was restored, he gave my mother £75 for it, which enabled her to give me a few lessons in restoring, and all the family a summer holiday! I tell this story to show the need for qualified scientists like Mr. Rawlins. I hope that when he retires from the National Gallery he will continue his good work. I think he could claim a great deal of the success that has been achieved at the National Gallery. Let us thank him for a fascinating lecture.

The vote of thanks to the Lecturer was carried with acclamation, and another having been accorded to the Chairman upon the proposal of Mr. A. B. Knapp-Fisher, the meeting then ended.

THE COMMONWEALTH EDUCATION CONFERENCE

A paper by

SIR PHILIP MORRIS, K.C.M.G., C.B.E., M.A.,

Chairman of the Commonwealth Education Conference, and Vice-Chancellor of Bristol University, read to a joint meeting of the Commonwealth Section of the Society and The Royal Commonwealth Society on Thursday, 11th February, with Dame Mary Smieton, D.B.E., Permanent Secretary, Ministry of Education, in the Chair

THE CHAIRMAN: It is a great honour to act as Chairman for so distinguished a speaker as Sir Philip Morris; but for anyone from the Ministry of Education it is also a very great pleasure, because he is one who has given to the Ministry through many years much wise counsel, and he has done much work for us as Chairman of a number of Councils and Committees.

The subject of the Conference to-day is one which must obviously appeal very much to the audience here and I myself am delighted to have the opportunity of listening to Sir Philip's account. All the reports which have come to me—I was not there myself—have emphasized what a remarkable spirit was engendered in the course of the Commonwealth Education Conference, in the way of deep interest and a real sense of community of interest and efforts. And that I am sure must have been due very largely not only to Sir Philip's own Chairmanship of the Conference, but to his management of the Steering Committee, the way he kept in touch with all the sub-committees into which the Conference broke up, and then pulled it all together at the end.

The following paper was then read:

THE PAPER

There were once three academics, sitting on the platform at Temple Meads Station—that is in Bristol—and they were watching the trains. But they got engaged, as academics will, in heated discussion and failed to observe the train which they were interested in arrive. It was only when the whistle blew and the guard waved his flag that they began to take real notice of what was going on. Two of them leapt from the seat and the other climbed up gently, for he was lame in the left leg, and they all ran as fast as they could towards the moving train. Two of them managed to embark. The third was caught by a ticket collector who told him that he was breaking a Bye-law of the railway company and had rendered himself liable to a fine not exceeding forty shillings, and a man of his age ought to be more sensible. And so on. And this man astonished the collector by saying: 'I assure you that all you say does not worry me a bit; what does worry me is that those two chaps came to see me off!' There is no harm in a moment's relaxation before beginning to attend to something which is of serious

consequence. And I assure you that I am here in no fit of absence of mind. I have got to be brief if I am to cover enough ground in the time; and to those who were at the Conference, I apologize on this, the only occasion, for telling them things which they already know so much better. For the rest, I thought my best plan was to give an eyewitness account, because in an eyewitness account impressions inevitably creep in and perhaps for impressions to creep in is better than to talk at large about impressions.

I think many of you have been engaged in arguments from time to time—rather on the basis of whether the egg or the hen comes first—on the question as to whether educational standards are a precondition of economic progress and stability, or whether it is only on the basis of economic progress and stability that educational progress becomes possible. The argument is inevitably circular, but at the Conference on Commonwealth Trade and Economics in Montreal, in 1958, Ministers of Finance quite adroitly avoided the main question but answered another one. They said that they were unanimously agreed about the great importance of education and training as an indispensable condition of development. And for the purposes of the Commonwealth Economic Conference, that is a sufficient answer to the $64,000 question, as to whether the egg or the hen comes first. It is enough to be satisfied, as I suppose all reasonable men are, that the two are inevitably interdependent, interacting on each other and incapable in fact of being separated. It is rather like the air a man breathes; the chemist can analyse it into its constituent parts, but if he analyses too much of it into its constituent parts, the chemist inevitably dies in the process.

The Conference was assembled from all quarters of the world, and it came together as a result of the decision of the Trade and Economic Conference in Montreal. That Conference had decided unanimously that the United Kingdom should mount in 1959 a conference of representatives of the Commonwealth Governments, to consider Commonwealth education. The delegates arrived from their various countries and first embarked on a series of visits in the United Kingdom, to see something of the brighter as well as of the seamier side of Dame Mary Smieton's bailiwick. They eventually assembled in Christ Church, Oxford; as it seemed to me, looking at them from the gate into Tom Quad, a rather motley, slightly disorderly group of people, not too sure where they were or what they had come for; but a large number, and all of them disposed to think that this, like all other conferences, would be badly organized and badly arranged; that they would be able to enjoy all the things which those who attend conferences always do enjoy; complaints about the staff, failure to find the necessary papers and all the usual kinds of grouses. Well, they were of course determined to have their complaints and have their complaints they did. But they all frankly admitted that they were having their complaints just for fun and that in fact none of them was justified.

Indeed, the staff—which was very generously, but not all that willingly, put at the disposal of the Chairman of the Conference for various purposes—by their example, by their behaviour and by their efficiency, did more perhaps for Commonwealth education than actually the Conference itself did. It was an

astonishing achievement that this curious, opportunistically aggregated group of various kinds of administrative, executive and secretarial types, unwillingly lent by all kinds of government departments, should have become a coherent, cohesive, willing and efficient staff.

The first main business of a conference always is to have an inaugural plenary session, and an inaugural plenary session we had. This one in retrospect makes me rather sad, because it turned out to be perhaps the last public appearance of Lord Halifax—a man who has had a direct and indirect influence on my life, certainly over the last forty-five years, from the time that I first met him as a very young undergraduate, and a man who clearly has had a big influence on world affairs. He in his own inimitable way lifted this motley collection from the level at which they had congregated and gave them the opportunity of a really good start. He appropriately quoted what H. G. Wells had said, that 'more and more the human future becomes a race between education and catastrophe', and he added, in his own words, that it was quite possible we were now on the 'last laps of that momentous contest'. He asked the Conference to get down to their task with a consciousness not only of the importance of the issues at stake, but also with the confidence that the results of their efforts could bring 'new opportunities and new hope to the young people of the Commonwealth' and thus 'expand the opportunity, the security and the future of all the countries in it'. The words are not many, but the meaning behind them is great; and it is very pleasant that the emphasis is on young people and opportunities for young people.

The High Commissioner for Canada, quite properly, spoke after him and he referred to the initiative which his government had taken at the Economic Conference in Montreal, about the institution of a brand new scheme of Commonwealth scholarships and fellowships; an initiative which had received the warm and unanimous approval of the Ministers of the other countries and had been put down as one of the items of important business for the Commonwealth Education Conference to attend to, so far as the details and what, in our Conference jargon, we referred to as 'the nuts and bolts' were concerned. Prior to the assembly of the members of the Conference in Oxford, I think it is only right to say that the United Kingdom had most effectively and efficiently discharged its responsibility for making arrangements for the Conference. All the preliminary arrangements had been made, and I think most of you will know how difficult it is for the working arrangements for the set-up of a Conference of this kind, for its objectives and for the subjects of study, all to be arranged in a thoroughly democratic manner amongst a large number of people, who arrive only a few days before the Conference is actually due to begin. But by the timely assistance of a very dignified garden party in Lancaster House, the Steering Committee of the Conference (which had not yet come into existence) was able to have a preliminary meeting, quite informal, and quite out of order. I am glad to say that, after a reasonable amount of discussion—not too much to interfere with tea, not too little to spoil the garden party or the Conference—the arrangements for the Conference were unanimously adopted.

It was decided that the Conference should proceed largely through committees and there was of course the inevitable Steering Committee in the background, which was to keep a general eye on the arrangements and how they proceeded; it should be responsible for devising arrangements for continuing co-operation and for any new subject which might emerge during the course of the Conference, and finally should be responsible for that almost impossible task of getting an agreed report drafted, amended, finally approved and circulated to the members of the Conference, before they dispersed.

The composition of the Steering Committee was very interesting. Anyone looking at the members of it, could not help reflecting upon the wide spread of climate and background of opinion, civilization, and of religion, which was represented round the table. Still more, one could not help being astonished that it was possible for a Steering Committee of this very complex and varied character to find a corporate sense of responsibility and urgency about its work. It was composed of the heads of delegations, together with the chairmen of the committees which the Conference decided to establish. Four committees were established, to deal with the four main subjects which it had been decided were the most important things for this particular Conference to attend to.

The first committee was to deal with the details of a scheme for Commonwealth scholarships and fellowships. The Chairman was a distinguished Canadian academic; many of us knew him in advance and all of us knew him very much better and liked him even more by the end of the Conference. I need not go into the details of this, because my talk is no substitute for reading a beautifully drafted and well printed sixty-five page paper which was laid before Parliament in August, 1959, and is obtainable—for what I still regard as a reasonable price, considering the quality of the reading matter—from Her Majesty's Stationery Office for the modest sum of four shillings.

The second committee was concerned with the supply of teachers, and this was of course a subject of very great interest. We very quickly discovered that there was a shortage of trained and efficient teachers in all parts of the world. There seemed at one stage almost to be a competition in declaring the greatest shortage. But soon commonsense supervened and the members of this committee began to realize that it was the degree of shortage and the enormous differences between the extent of the shortages in different countries which was really much more important than the simple, rather hackneyed statement that 'everybody, of course, is short of teachers'. And this committee did seriously and genuinely grapple with this problem and they succeeded, I think, in creating a much more real and genuine perspective for all of us—certainly they did for me. I do not think anyone here will be offended if I say that the degree of shortage which exists in some countries of the Commonwealth would be regarded as affluence beyond the wildest dreams of anybody in some other countries in the Commonwealth. And such indeed is the case.

The difficulty was to quantify the requirements and equally to quantify the extent to which people could, if they would, assist those who were less fortunately placed than they were themselves. The interesting thing was that the repre-

rentatives of various countries became more and more persuaded of the necessity of helping other people, even though the help they gave was at a price. And they seminded me of something which I learnt at my mother's knee, from my mother, when she said: 'Philip, if giving something does not cost you anything, it is not really a gift'.

The third committee dealt with the training of teachers: as you will see, closely related to the first but equally clearly distinguishable from it. For in any great enterprise you have to start from where you happen to be, and the trained teachers, the supply of them, the availability of them and the shortage of them are all an essential part of the situation from which the enterprise begins. The training of teachers is dynamic and is the only process as yet invented which begins to rectify shortages in the current supply of teachers from time to time. It is itself, of course, as a problem very greatly increased by the shortage of trained teachers, because those who have ever been concerned with the training of teachers know only too well how difficult it always is to assemble enough of the right people to take the responsibility of admitting new entrants, in ever increasing numbers, into a most responsible profession. This committee, so far as I was able to see, did a very useful and profitable piece of work. What will result from it depends upon whether governments and educational systems at home are willing to catch the kind of idealistic perspectives which their representatives at this particular conference found it necessary to adopt.

The fourth committee was concerned with technical education. I suppose it is no secret, and I doubt whether it is even news, that we live in a scientific and technological age. It is probably true that economic advance, industrialization and the gradual development of, as yet, underdeveloped territories, depends to a large extent upon the availability of those who have technical and scientific knowledge and technological skill and mastery. But I learned some new things in the discussions of this particular problem. They were things which I ought not to have had to learn, but it may well be that there are others here who could usefully learn the same lesson. I learned as a fact, rather than as a set of words on paper, that technical education and scientific education and technological competence, all are impossible, unless they can grow out of and be built upon a sufficient standard of general education. It is not that that is my idea and my hope and my wish; it is just a fact in the case. It is not possible to run before you can walk, nor is it possible, normally, to walk until you have had experience of some other form of locomotion. And so it is with scientific technical and technological education. A real understanding and appreciation of the tools for doing anything literate and figurative are a precondition of effective technical or technological advance. I learned secondly, again as a fact rather than just as a few words on a piece of paper, that it is very difficult for boys and girls in a country to acquire through their pores what is meant by factories and industrial production by machines, machine lines, machine production and the rest, if all those things are completely outside their experience. They cannot go round the corner and see it; there is no way in which they can acquire, in these particular conditions, all those rudimentary experiences upon which so much

in the whole educational process depends. In this country, with the slow evolution of factory, industry and all the things which have come since, boys and girls have grown up with the experience; they have been in the middle of it. It has been part of the nutriment which they have taken in in the course of growing up. There is at present no lack of opportunity for good adolescent experience of good industrial practices.

The third thing which I learned was not unlike the first. It is that so frequently those who have skills which they could teach lack the educational equipment to enable them to impart what they need to pass on to a rising generation, together with the skill of which they can merely demonstrate. And those, unfortunately, who have the literacy, so frequently lack all the necessary skills. It seems to be a curious commentary upon the way in which education in the last fifty years has developed, that those who can think often cannot do, and those who can do, all too frequently cannot think. Somehow or other, there will have to be more people in the future like me—happiest when they are doing, and finding it very hard work to be required to think.

Those were the four committees, and they all produced material which the Secretary-General and his staff (Mr. King and Mrs. Chitty notably) put through the mangle, put through the washtub, and produced in the form of a draft. We had it in mind to incorporate in our draft report some winged words upon the real purpose, content and profundity of education. This was a very high objective, and if we could have done it well it would have been a very desirable thing to do. But few people know how difficult it is in fact to get a group of people saying the right thing about an ideal. It would perhaps be highly impolitic (but then I am afraid I am frequently guilty of being extremely foolish) to remind you of the artist's comment on the giraffe. He said it was an animal designed by a committee. I am not sure that it is quite fair to the giraffe, but I do not mind whether it is fair or unfair to the committee.

The Steering Committee produced with very great difficulty a complete draft of the report, and then, as you will of course fully recognize, amended it again and again. But within twenty-four hours the original draft had been amended and the amended draft had been produced, and peace supervened by six o'clock on the evening before the report was to be distributed to all delegations—at nine a.m. It still surprises me that that should have been possible. With the Secretary-General, Mr. King, I made a tour of people who were working the typewriters and duplicators, on the first occasion at about quarter to two, and on the second occasion at about half past three, in the morning. The operations were completed at something like three o'clock on the first occasion and a little before four a.m. on the second occasion. If Dame Mary Smieton wants praise for the educational system over which she presides, the performance of this particular staff in this particular matter is the finest satisfaction that she is ever likely to get. It really was a remarkable achievement.

There is one very interesting misprint which escaped the eye of Mrs. Chitty, escaped the eye of Mr. King, and may of course have been introduced by one of the typists brought up in one of our famous modern schools. I quoted Lord

Halifax's remark that we might be entering upon the 'last laps of that momentous contest'. The typist had thought it would read better if an 'e' were put on the end of the laps.

So the report was published and laid before Parliament, and all the documents relating to the Conference have been published since. And what, in the last three minutes which I am allowed, does it all amount to? I remember when I was a very young undergraduate, I heard William Temple, before he became Archbishop, deliver one of the most remarkable addresses I have ever heard on the impact of Christianity upon humanity. And it happened that I was sitting by one of the gentlemen of the press who had come to report on this particular meeting. He sat with his book open, with his pencil poised; the book remained open, the pencil remained poised. At the end of the address he shut the book and said, 'There is no news in any of that'. And I think it may well be the case that there is no news in anything about this particular Conference. It would on the other hand be a very great mistake to think that there was nothing of significance. I myself think that there are perhaps four things which I would single out as really meaning something in terms of human progress, and in particular of Commonwealth progress. For the first time reality was given to the idea that the Commonwealth countries had a common concern in educational progress throughout the Commonwealth: a *common* concern; not that they all had their separate concerns which they ought to know about, but that they had between them a common concern for educational difficulties wherever they occurred. The second significant thing was that despite the existing close links of association, regular contact on educational subjects between Commonwealth countries and Commonwealth governments had not as yet reached the stage where it could be said that the countries of the Commonwealth were in vital contact upon the matter which was so essential to their economic well-being and to their future.

The third thing was that if the Commonwealth countries really had a common concern, they ought to meet and renew their obligations and repeat the exercises which would bring home to them the fact that a common interest means that some of the problems of others become your own. It is not that you are your brother's keeper, it is that your brother's misfortunes are indirectly and certainly yours if you ignore them too long.

And lastly, it became slowly appreciated by all members of the Conference that, the Commonwealth being in a dynamic state of evolution, it was really essential that somewhere in the Commonwealth there should be a centre to which countries could turn to assist them to develop a series of bilateral contacts, which seem to be the inevitable future pattern of Commonwealth co-operation.

So it was decided that an *ad hoc* committee should meet in the autumn with a view to completing the arrangements for the establishment of the Commonwealth Education Liaison Committee, which should have its own small staff. It was agreed that this Committee, which should exercise no right of interference, and no duty of initiative, but would bear a general responsibility for assisting everybody in need, should be brought into existence as a centre of

Commonwealth co-operation until the next Conference, to be held in New Delhi in December, 1961, or January, 1962, should take place.

Last, two things that can be said shortly. In this country, the United Kingdom —which I now address as an official of the Commonwealth and not as an official or a Chairman appointed by the Government of the United Kingdom—the greatest requirement is that it should change its attitude towards experience in other parts of the world. We have the deep-rooted conviction that somehow or other anything which is done anywhere else is an interruption in a man's career and necessarily a disadvantage to it. We should, before it is too late, pause and consider. The Commonwealth comprises 660 million individual people with souls to be saved and bodies to grow and develop, and 660 million people are far more important in fact than a greater or a smaller measure of success or apparent efficiency in specialisms and specialities of any kind or sort. We ought to realize that if this great Commonwealth makes sense, as I have not the remotest doubt it does, it is our bounden duty to know a great deal more about the 560 million who do not share much with us either in background, in experience of civilization to date, in ideals, in religion, or indeed in any of the things that make it easiest for men and women to get on together. Surely it must be true that anything which enabled a rising generation in this country to know more and more of the 560 million of which they know so little at present, must be of much greater advantage to humanity than just an extra two marks either at O level or at A level.

Secondly, I want to read, if I may, a few words which begin the report of this particular Conference. It is so beautifully laconic that it is to my mind elegant and beautiful.

> The Commonwealth Education Conference was held in Oxford, England, from 15th to 28th July, 1959. The President of the Conference was the Right Honble. the Earl of Halifax, Chancellor of Oxford University. The Conference was attended by delegates from all Commonwealth countries, the United Kingdom, Canada, Australia, New Zealand, South Africa, India, Pakistan, Ceylon, Ghana, the Federation of Malaya, the Federation of Rhodesia and Nyasaland. Representatives from the following colonial territories attended it in an advisory capacity as part of the United Kingdom delegation: Aden, British Guiana, British Honduras, Fiji and Western Pacific High Commission; Hong Kong, Kenya, Malta, Mauritius, Nigeria, North Borneo, Sarawak, Sierra Leone and Gambia, Somaliland Protectorate, Tanganyika, Uganda, the West Indies and Zanzibar.

This wonderful constellation of countries which, by providence or by a fortunate accident, by circumstance or by force, have come together in a profitable relationship, ought somehow or other to be welded into an even more powerful instrument in the interests and in the service of humanity.

THE CHAIRMAN: I am sure you would wish me on your behalf to thank Sir Philip Morris most sincerely for his paper. It was a wonderful practical description of how the Conference worked, but it also contained much in the way of the conclusions to be drawn from it and the intangible results from it.

What was borne on me particularly was the responsibility that rests not only on

all the official bodies that have to follow up the conclusions of the Conference and work out the practical schemes which were devised, but also the responsibility that rests on all of us to make known to a wider audience the intangibles that came from that Conference in terms of the living nature of the Commonwealth—the dynamic stage, as Sir Philip said, that it has reached.

We are fortunate to know that Sir Philip Morris is associated, in the follow-up, with the Commonwealth liaison unit, because he will be able himself to help carry forward all the impressions, the thoughts, the things that need to be done which he has made so very living.

The only other thing I should like to say is how much pleasure the award of the K.C.M.G. to Sir Philip gave to everybody concerned with the Conference. On behalf of all those present here, I should like again to thank Sir Philip very much for the way in which he brought that Conference to life for us.

The vote of thanks to Sir Philip Morris was carried with acclamation, and the meeting then ended.

GENERAL NOTES

ROYAL DRAWING SOCIETY'S EXHIBITION: AWARD OF THIS SOCIETY'S BRONZE MEDAL

'In the Ring', by Christine Forrester

In 1957 it was decided that the Society should resume its former practice of offering the award of a bronze medal in connection with the Royal Drawing Society's Exhibition of Children's Art. The first subsequent award was made in 1958 (see *Journal*, Vol. CVI, pp. 456, 555).

The Society's Bronze Medal has this year been awarded to Christine Forrester for her painting entitled 'In the Ring' (reproduced on p. 541), which was chosen, from among some 200 pictures included in the 1960 exhibition of Children's Art, by Mr. William Johnstone, Principal of the L.C.C. Central School of Art and Crafts, and a Member of Council of this Society, and Mr. R. R. Tomlinson, President of the Royal Drawing Society. Miss Forrester is 15 years old, and a pupil at Albany Secondary Modern School, Cardiff.

By the time this note appears the 1960 exhibition of the Royal Drawing Society will have finished its London showing. It will next be seen at Brighton from 16th July to 13th August, and then at Sunderland (27th August to 25th September), Ilford (15th October to 12th November), Wolverhampton (3rd to 31st December) and other towns in the Midlands and North.

THE ROYAL ACADEMY SUMMER EXHIBITION

The one hundred and ninety-second exhibition of the Royal Academy is not among the more rewarding summer miscellanies of recent years, though distinction is conferred by the memorial group of paintings by the late Stanley Spencer, by the presence more than the brave performance of the veteran Mr. John, and by the works of such esteemed artists as Epstein and Sir William Coldstream, who are represented here for special reasons. The exhibition calls, however, at this hour, less for a belated review than for reflections. And the first, which even its tireless detractors would concede, is that the hanging committee continues to be as liberal-minded as anybody could conceivably be, placing two characteristic abstracts by William Gear in the main gallery, and siting as conspicuously *The Communicant* by F. E. McWilliam, who has stylized his veiled figure in the form of an enclasped bronze column. It is clear that other advanced and admired artists would be equally welcome if they chose to send. To some extent they may be intimidated by the apparently inescapable necessity of over-crowding the walls; but at the same time it is a fact that the prejudice of the more *avant-garde* dealers, to whom successful artists may feel beholden, is a handicap to the honourable intentions of the Academy to-day.

Its progressive efforts in late years deserve indeed to be saluted, as they rarely are by very young judges who can only guess at the parochial attitude which persisted for years before the war. One marvels in retrospect at the self-assurance of the few artists of serious consequence who then risked their reputations in company generally unworthy of them. Sickert, not disdaining any lime-lit stage, was one; Stanley Spencer another so-called 'rebel', who resigned in 1935 to return in more enlightened times after the war. In the present exhibition a wall is rightly devoted to five of Spencer's more important subject pieces which include the early and mysterious vision of *The Centurion's Servant*—the great bed with its occupant and rapt kneeling figures looming with almost spectral effect amid the encircling gloom. The centre-piece here is the immense and unfinished *Christ Preaching at Cookham Regatta*, which shows that whenever the artist could recover the intensity of his earlier religious spirit, as he does here, such apparent incongruities as a straw-boatered Christ can carry such conviction as to reconcile them in the spectator's mind to the almost medieval wonder and freshness of the whole conception. Rare indeed was that union of mystic and ebullient chatterbox, commemorated also here in the last self-portrait to remind us of the artist's fortitude at the end.

Though election was assured him, Epstein stood always apart from the Royal Academy, which now does honour to the eminence of the sculptor and his last sitter. The *Princess Margaret* is a vital three-quarter length bronze, powerfully suggestive of a physical presence in the nervous modelling of the form, though the personality might be hard to identify without the clue of the Riband, so highly individual, not

to say alien, is the interpretation. One can visualize Epstein's eye falling not unfavourably elsewhere on the *Wounded Deer*, a bronze from Francesco Coccia in a contemporary Italian mode reminiscent of Marini's, and on a brooding figure of a seated girl by Sydney Harpley, a more familiar exhibitor.

This year's exhibition recalls not only the national loss of Epstein and Spencer, but also the departure of such members as Sir Alfred Munnings and James Bateman whose reputations were wholly created through the Academy. It is sad that Bateman died, as one must suppose, a disappointed man, for his earlier pastoral landscapes with cattle, beautifully represented here, are knit together not only by their composition but also by a consistency of feeling into a coherent whole in which dignity and candour are united with a certain solemn stillness. One day his painting may be reappraised, and compared perhaps with the earlier work of Gilbert Spencer (the period of *A Cotswold Farm*) in that English tradition of reverence for earthy things which descends from Madox Brown.

Such work, however, is all too liable to be passed over in an assemblage of over fifteen hundred exhibits in which the raw expressionism of a Bratby or the calculated audacities of a Ruskin Spear are well designed to make their popular mark. Nevertheless, a most convincing portrait of *Harry Locke*, a full-length in severe black and white, is a reminder that Mr. Spear can be a highly serious artist when he chooses, and almost invariably at his best nowadays in searching portraiture. Carel Weight has, among other things, a strangely compelling fantasy very much in the spirit of the Belgian irrational artist Ensor, and the Royal College of Art is ably represented also with paintings by Robin Darwin and Robert Buhler. A quaint and haunting little picture of a beggar pushing his loaded pram is among the increasing number of works of a London group nature which are slowly transforming the Academy.

NEVILE WALLIS

DESIGN CENTRE AWARDS, 1960

On 19th May His Royal Highness the Duke of Edinburgh visited the Design Centre in the Haymarket and presented certificates to the manufacturers whose products have been distinguished by Design Centre Awards for 1960. These awards were made on the recommendation of a specially appointed selection panel, who chose, from the entire range of objects shown in the Design Centre during 1959, sixteen designs outstanding for originality, workmanship, economy or some other special quality of significance in industry.

As in previous years, a high proportion of the sixteen awards have gone to the furnishing industries, but the judges' selection this time also includes street lighting columns, electric light fittings, textiles of various kinds (amongst them a drip-dry lace), a camera, a wall-paper, oven-ware, glass and china. In the last-named category a design for a range of table-ware, entitled 'Apollo', has been singled out for the additional award of the Duke of Edinburgh's Prize for Elegant Design. 'Apollo', in plain white china, was chosen for this prize by virtue of its pleasing shapes and practicability in use. The designers are Neal French, Des. R.C.A., and David White, who developed the original models for it whilst they were students at the Royal College of Art. Mr. French and Mr. White are the joint recipients of this distinction: the actual prize, which they are allowed either to design for themselves, or to commission from another designer, will be presented to them by the Duke of Edinburgh next year.

All the Design Centre Awards are on view until 25th June.

EXHIBITION OF AUSTRIAN PAINTING AND SCULPTURE, 1900–1960

An exhibition of Austrian painting and sculpture from 1900 to 1960 is on view at the Arts Council Gallery in St. James's Square, London, S.W.1, until 4th June. The exhibition, which has been organized by Dr. W. Hofmann on behalf of the

Austrian Ministry of Education, consists of nearly 100 paintings and some twenty-five pieces of sculpture, and presents a cross-section rather than a comprehensive survey of the last sixty years. It is designed to show the continuity of the development of Austrian art, perhaps intensified by the isolation of the war years, and its links with that of other European countries. Beginning with the artistic revolution in Austria at the turn of the century, in which Vienna played an outstanding part, the exhibition includes the work of the pioneers of expressionism, such as Kokoshka, who has won international fame, Klimt and Schiele.

There is a charge of 1*s.* 6*d.* for admission to the exhibition. The hours of viewing are from 10 a.m. to 6 p.m. on Mondays, Wednesdays, Fridays and Saturdays, and from 10 a.m. to 8 p.m. on Tuesdays and Thursdays. The exhibition will be shown later at the Municipal Art Gallery, Middlesbrough (18th June to 9th July) and at the Leicester Museum and Art Gallery (23rd July to 13th August).

BRITISH ASSOCIATION ANNUAL MEETING, 1960

The 122nd Annual Meeting of the British Association for the Advancement of Science will be held in Cardiff from 31st August to 7th September, 1960, under the Presidency of Sir George Thomson, F.R.S., Master of Corpus Christi College, Cambridge. For his Inaugural Address, Sir George has chosen to speak on 'The Two Aspects of Science'—the practical and the philosophic—and to consider the effect which science has had upon its creators.

This awareness of the relationship between science and 'the human situation' gives rise to certain emphases in this year's programme as a whole, and to one major innovation: the whole of Monday, 5th September, will be devoted to a practical review by a number of distinguished scientists and experts of the issues arising out of the world food and population position to-day. All those present at the meeting are invited to take part.

In addition to the proceedings of the various sections, the programme for the meeting includes illustrated lectures for young people and a Science in Schools exhibition, continuous showing of scientific films, and a wide choice of social functions and excursions.

No scientific qualifications are required for membership of the British Association, and all who are interested in science and its impact upon society can join and attend the Cardiff Meeting without any formalities. Adults can become Associate Members for a fee of two guineas; students and school children for ten shillings. Application should be made to the Secretary of the Association (at 18 Adam Street, Adelphi, London, W.C.2), who will also supply copies of the preliminary programme summarized above.

OBITUARY

We record with regret the deaths of the following two Fellows of the Society:

MR. A. DIGBY BESANT

Mr. Arthur Digby Besant, B.A., F.I.A., who died on 29th April, aged 91, had been associated with the Clerical, Medical and General Life Assurance Society for over sixty years, and for much of that time guided its affairs. He entered the Society's service in 1890, and was appointed General Manager in 1906 and a Director in 1933. He retired in 1957. Mr. Besant was a former President of the Institute of Actuaries, and a Senator of the University of London. He published a history of the Clerical, Medical and General Life Assurance Society, and a study of his own family pedigree. His mother, Mrs. Annie Besant, was the well-known adherent of Theosophy, a one-time President of the Indian National Congress, and sister of Sir Henry Trueman Wood, for many years Secretary of this Society.

Mr. Besant was elected a Fellow of the Society in 1918, and became a Life Fellow in 1952.

MR. R. J. S. MUIR

Mr. Ronald James Samuel Muir, C.M.G., who died on 25th April, aged 60, was for over twenty years a leading figure in the Australian Sugar Industry, with which his father and grandfather had also been associated. He was born and educated in South Australia, and in 1923 was appointed Chief Cane Inspector at the Mulgrave Mill, then one of the largest in Queensland. He joined the Queensland Cane Growers' Council as Assistant Secretary in 1930, and eight years later became General Secretary to the Council. He subsequently represented his industry on a number of major committees of inquiry, including two Royal Commissions, and in the post-war years travelled overseas frequently on its behalf. From 1949 onwards Muir was closely concerned with the negotiations for the United Kingdom/Commonwealth Sugar Agreement, and he was Australian Representative at the International Sugar Conferences in London in 1953, New York in 1956, and Geneva in 1956 and 1958. He was awarded the Queen's Coronation Medal in 1953, and was made C.M.G. in 1956.

Mr. Muir became a Fellow of the Society in 1940.

NOTES ON BOOKS

WATERLOO. *By John Naylor. London, Batsford,* 1960. *21s net*

The bibliography of the campaign of Waterloo is already a long one but, even to-day when so much is no longer in dispute, the reasons why some of the principals acted in the way they did continue to interest students.

This little book of some two hundred pages forms one of the series on British Battles which the publishers are producing with the object of giving a factual description of the events leading up to each selected action and, by linking this to the personal accounts of those engaged, presenting a coherent picture of the warfare of the time. In 'The Hundred Days' three separate armies, commanded by the foremost captains of the age, were involved and it is no easy task to compress the whole story into the space allotted. Even if he has thrown his net rather wide, the author has acquitted himself well. He has marshalled his material into three main parts. The first deals with the preparations and compares the French soldier and his arms and tactics with the British. The second covers the fighting at Ligny, Quatre Bras and the pursuit, whilst the remainder is devoted to the Battle of Waterloo itself. When considering the high level conduct of the campaign, he records the principal orders issued and discusses the reasons for the forward concentration of the Allies; the stalemate at Quatre Bras; the wanderings of Derlon's Corps on the 16th; the ineffectiveness of the pursuit and Wellington's detachment at Hal. On each of these points his criticisms are well presented and fair. The part played by Blücher is simple to understand and the author is primarily concerned with the operations conducted by the Duke and his formidable adversary and the ways in which the plans of the latter were bedevilled by such actors in the drama as Soult, Ney and Grouchy.

His description of the actual fighting is not quite so well done. The individual views of the selected contestants, which are included, are not always related to the whole picture and sometimes spot-light a relatively inactive part of the front at the expense of vital contemporary actions taking place elsewhere. Insufficient space is thus allotted to the defence of Hougoumont, which made the right flank so secure on the 18th, and Colborne's deployment and final charge with the 52nd was surely one of the crowning episodes of a hard-fought day.

It is a pity that so much reliance has been placed on Mercer's *Journal*, and that this source should have been used for much of the Artillery detail. Mercer was certainly the most inexperienced Horse Artillery Troop commander present and however gallant his account of his own actions may appear, he was not lightly forgiven

by his superiors for the almost total destruction of his Troop. Whinyates, whose letters are extant, is a far better authority on the subject of Rockets. The use of 'shrapnel', which gave the British Artillery so great an advantage, is not mentioned and though the careful instructions issued by the Duke for the Gunners to take refuge in the *squares* is recorded, the reason for it is omitted. This was that, by the drill of the period, when the Infantry formed square, a gap of about a hundred yards was automatically left between the gun line and the front face of the nearest square in rear. This left the Gunners at the mercy of the attacking cavalry. It is, of course impossible, in the space available, to mention many of the units in any of the arms by name, but when referring to Maitland's famous charge, it would have been only fair to state that it was the fire of Bolton's Brigade of Guns which stopped the second column of the Old Guard at about thirty yards rise, and by throwing it into confusion gave Maitland his chance.

Nevertheless this is a well-written and carefully compiled account of the campaign, supported by simple but good maps and innumerable sketches and illustrations, many of which have not often been reproduced. The whole production is first class and even if the result may appeal more to the student than the expert, the latter would be well advised to keep a copy handy for ease of reference.

H. B. LATHAM

STAINED GLASS—HISTORY, TECHNOLOGY AND PRACTICE. *By E. Liddall Armitage. London, Leonard Hill,* 1959. 75*s net*

In art histories stained glass is customarily regarded as essentially a medieval art, the glories of which began to depart with the Renaissance and to be entirely lost by the eighteenth century. Until recently it continued to be thought of as a lost art, but now in the mid-twentieth century we are, it seems, at last enjoying a revival, not merely in the imitative sense as in the attempted revival of the nineteenth century, but a revival leading to new and vivid forms of expression in the medium. Mr. Liddall Armitage, assisted by a wide range of illustrations, makes this abundantly clear; and if one were to select the finest examples from the 117 plates—some of which are in colour—the choice would reasonably fall on those of the twelfth to the fourteenth centuries and on those of the twentieth century.

Mr. Armitage follows a historical section, where each century is given a chapter, with one devoted to technology which occupies nearly half the book, and which, being by an experienced practitioner in the art, is particularly valuable to the student, who is taken in easy stages through the various processes and techniques.

The question that is often asked, to which the Victorian pioneers found only a partial answer, is why stained glass became a lost art. The answer is constantly implied in the historical section and in the concluding section on modern practice. Mr. Armitage regards the eighteenth as the century in which the craft degenerated to its lowest level of aesthetic production, and Reynolds' window in New College Chapel, Oxford, as its greatest futility. He makes the doubtful suggestion that if Reynolds had concentrated his heart and mind on the realization of the Nativity he might have produced a masterpiece. The explanation is rather one of appreciation of the quality of the material, for as Mr. Armitage more rightly says later: 'the artist was thinking in terms of paint and chiaroscuro and not at all of glass'. That is the point, and the gradual decline of the art of stained glass windows was due to imitating the effects obtained in oil painting. A condition of success in all the visual arts is an appreciation of the unique untranslatable qualities of the artist's material. The negation of this is the remoteness of designers from the actual makers of the stained glass windows in so much Victorian commercial production, scathingly described by Mr. Armitage. He shows too that the feeling for patterns of beautiful pieces of glass is more than anything the spirit of the modern revival. 'The Sisters of York

tell no story but the story of beautiful pieces of glass put together by a good craftsman', says Bo Beskow in the very valuable concluding section which gives accounts, provided by themselves, of the aims and principles of most of the leading stained glass artists of to-day. They include such artists as Farrar Bell, Ervin Bossanyi, Jan Brazda, Max Ingrand, Arthur Buss, Carl Edwards and Lawrence Lee; illustrations of their work form many of the plates.

This is a handsomely produced book worthy of its beautiful subject. The illustrations are of the utmost clarity, as they should be in a book of this kind, while those in colour are of a very high quality.

ARNOLD WHITTICK

MEMOIRS. *By Alexandre Benois. London, Chatto & Windus, 1960. 30s net*

A recent exhibition in London of the scene and costume designs for the Tchaikovsky ballet *Casse Noisette* served as a reminder—if indeed a reminder was needed—of the vast contribution which Alexandre Benois has made throughout his long life to the cause of Ballet. Prince Peter Lievens in his book *The Birth of Ballets-Russes* pays him a deserved tribute. Bakst, he says, had a great influence on the ballets, Fokine played an important part in their creation, Stravinsky in their music, and Nijinsky's genius in their interpretation, but 'if Diaghileff in his early years had not had that chance meeting with Benois, there would have been no Ballets-Russes'.

Benois himself has recounted the story of his connection with the Diaghileff Ballet in his *Reminiscences of the Russian Ballet*. In *Memoirs*, the first instalment of his autobiography, he looks back with affection and delight on the days of his childhood in the St. Petersburg he so dearly loved.

Imperial Russia, though only removed in time less than fifty years, has the remoteness of a fairy tale; and like all fairy tales this enchanted existence has an irresistible fascination.

The Benois were an intellectual, cosmopolitan family. France, Italy and Germany all contributed to their make-up. One of Alexandre's sisters married the brother of George Edwardes of Daly's and the Gaiety Theatre fame, and Peter Ustinov, who in his preface to this book pays an affectionate and understanding tribute to the author, is a great-nephew. Alexandre himself had not one drop of Russian blood but he proudly describes himself as a child of St. Petersburg. The family was almost exclusively connected, one way or another, with the Arts—the father was an Imperial Architect, the grandfather had rebuilt the Bolshoi Theatre after its destruction by fire, and with his son had been responsible for the construction of the Mariinsky Theatre. It is not surprising that the boy, the youngest of the family, growing up in a highly developed cultural atmosphere, displayed early in his life a discriminating enthusiasm for the Arts. In his youth he must have been a remarkably perceptive child and in old age he retained an equally remarkable memory, to which was added a facility for recreating these many memories of a way of life which has completely vanished from the face of the earth. He conjures up the Peterhof where he played and looked in wonder at the magnificent palaces he was later to reproduce so delightfully in watercolour. He recounts the fascinating toys of the period, the kaleidoscope, the innumerable toy theatres with bright sheets of characters to be cut out, marionettes brought from Venice. For especial treats there was the home Magic Lantern show—gaudily coloured slides projected, some of course upside down, in a darkened room, thick with fumes of paraffin, burnt soot and over-heated lacquer. Punch and Judy (Petrushka to the Russians) performed in their own courtyard, an early inspiration to the designer and part-author of the ballet. Shrovetide funfares—another *Petrushka* link—jostle with military parades—(the Benois' home was on the route to the town barracks)—with drives through streets deep in snow in sleighs laughing with bells. As may be imagined, his appetite for plays, operas and ballets increases in intensity as he grows in years. This period kaleidoscope is brought to life with the ease of the

showman in *Petrushka* as with his magic flute he brings life to the crude sawdust stuffed figures.

Since this review was written, this lovable and revered artist has passed away from a world heavily in his debt. His memory and his achievements will endure.

AUBREY ENSOR

SCIENCE (CHEMISTRY, PHYSICS, ASTRONOMY). *Edited by J. Bronowski, Sir G. Barry, J. Fisher and Sir J. Huxley. Illustrated and designed by Hans Erni. London, MacDonald, 1960. 45s net*

This is a beautifully illustrated elementary introduction to the physical sciences, a large book (11 x 8½ inches), rich in diagrams, in photographs and in superb fantasy illustrations. It is aimed at the young—shall we say 10–18-year olds—but can be studied with profit by every parent.

There are 14 contributors, assisted by R. F. Binckerhoff, R. A. Gallant, A. Garratt and P. Moore as advisors: the two former being well-known American science writers, the two latter well-known British television broadcasters.

An unbelievable amount is compressed into the effective 350 pages, yet the content is not overloaded. The level throughout is good and the greatest care has gone into the explanation of the material. The method used is essentially that of historical evolution, not an alphabetical sequence. There is thus occasional deliberate repetition, but this is a good thing in itself.

We are informed that this is the first member of a series in which later we shall meet other branches of knowledge on a broad scale. It is right that the physical sciences should occupy the first volume, but this reviewer would personally have liked a rearrangement of matter, for here chemistry precedes physics, and surely this is the wrong way round. The result is that we find nuclear physics, the electron microscope, cosmic rays, atomic structure etc. all, strangely enough, allocated to the *chemistry* section.

Logically it is much easier to arrive at molecular structures first *via* the atomic processes of physics. However, such a criticism is like looking a gift-horse in the mouth, for as long as the material is described the logical presentation is not too important in such a book as this.

There are occasional minor infelicities. Some of the coloured pictures are overloaded with diagrammatic detail, some slightly illogical scientifically. One, for instance, has on it Democritus, Dalton, Pasteur and the Curies. We know Pasteur was a chemist of great distinction, but surely even the more knowledgeable amongst the young will still think of him in another field than this. Spelling tends to follow American forms, as if the book in the first instance was designed for the American market. Personally this reviewer objects to seeing 'molded plastics' in a book produced in and for this country. It is not for scientists to arrogate to themselves the 'correction' of English spelling. But again this is a mere minor point in production, and to most of us, not of too great a significance.

Although the sections are more or less equally divided between Chemistry, Physics and Astronomy, there is a good deal of necessary overlap, and in addition also a good deal of what is pure engineering. Two especially good parts are those on acoustics and on optics. The astronomy section is novel in its approach, original, vivid and exciting, and it presents a great mass of data too.

The book ends with a 1,000-word glossary of scientific terms in Chemistry, Physics and Astronomy.

One can only level a single really significant complaint at this delightful book. It is expensive. It is so readable, so packed full of material, and so beautifully illustrated that it deserves to be widely read by children, but the formidable price is bound to restrict sales. Not that the book is overpriced, for it has an astonishing number of

illustrations, perhaps something like a thousand, and it is very well bound, to stand wear and tear.

One word of warning to the parent. This is largely a boy's book, for although it will excite the boy, the girl will likely find it tedious. Girls are just not interested in pictures of ram jets, ultrasonic drills or automobile storage cells (using, we note, 'sulfuric' acid).

S. TOLANSKY

SHORT NOTES ON BOOKS

THE PRACTICE AND HISTORY OF PAINTING. *A Book for Schools. By John Mills. Introduction by A. E. Werner. London, Edward Arnold,* 1959. 21*s net*

The artistic, technical and historical aspects of painting, and their interaction, are all covered in this book. The first part is devoted to a thorough examination of 'Materials and Methods' useful to students, and the second to 'A History of Painting in Europe'. There follow a glossary of terms, a list of galleries in this country, the Commonwealth and the U.S.A., an index and 70 illustrations.

BYZANTINE ICONS. *With an Introduction and Notes by David Talbot Rice. London, Faber (Faber Gallery of Oriental Art),* 1959. 15*s net*

The ten beautiful colour reproductions in this monograph are of icons from two sources: the Monastery of St. Catherine on Mount Sinai, and the assembly of outstanding examples of this art made for the Byzantine Exhibition (shown in Edinburgh and London) in 1958, which was organized by Mr. Talbot Rice.

FROM THE JOURNAL OF 1860

VOLUME VIII. 29*th June*

DISRAELI AT THE SOCIETY'S ANNIVERSARY DINNER

[*The* 106*th Anniversary Dinner of the Society was held at the St. James's Hall, Piccadilly, on* 22*nd June,* 1860. *Disraeli (then leader of the Opposition in the House of Commons) took the Chair, and spoke at length, working up to the following peroration.*]

How, then, are we to maintain and to increase, I hope, not only the excellence, but I will venture to say the supreme position which this country occupies in every respect, unless we make an Englishman, whatever his class, position, or duty—whether he is a cultivator of the soil—whether he is a manufacturer, or a mechanic, or a labourer—whether he is engaged in intellectual or manual service—worth more, and trebly more than the men of any other country. Unless we place that aim and object before us it is absurd to suppose—it is the height of egotism, benighted egotism, to suppose that with the limited population of this country we can maintain the position which we now occupy. And it is only by effort in every class, effort not limited to any particular class, but in every order in this country, effort to excel, that we can maintain the position which this country now occupies. That is the principle for which you are striving, and the education of the artizan is the method by which you are carrying it into effect. I venture to impress this upon you, because it appears to me that on an anniversary meeting it is of very great importance that a society should clearly understand why they have failed, if failure has been their lot, why they have succeeded, if triumph has been their portion. This is a society which has existed beyond the experience of any one generation of man. It has a

venerable character alone from that circumstance, which entitles it to the respect of the country at large. In old days great things were done; in modern days great things are done. You have had in the interval periods of decline. It becomes you to consider why you succeeded at the beginning of this career, and why, when a moiety of this century had passed, you were on the point of failure. It is because a hundred years ago when you were founded, and for thirty years afterwards, you were adapted to the circumstances of the times in which you lived; and fourteen or fifteen years ago, when you were on the point of extinction, you had amongst you able men, and especially men who understood the circumstances of the times, and adapted their exertion to those times. You must draw your conclusions from these facts. There is no use in having lived a hundred years if you have not the advantage of experience to guide you. I think you ought to adhere to the principle which you adopted in 1851—that you ought to devote yourselves to that which has already been characterised by success—that you should accept, as your great office, that which no other association has appropriated to itself—namely, as I have already said, the education of the artizan of this country. You should still continue your efforts to increase his knowledge, and refine his taste, and advance his skill, and thus improve the manufactures, and thus stimulate and strengthen the commerce of the country. You should not allow yourselves to be influenced in your course by the politics and gossip of the day. We live in times when we 'hear of wars and rumours of wars', but the ministers of the country did not shut up the colleges because there was even a civil war; and a Society that arrogates to itself the high title of the Society for the Encouragement of Arts, Manufactures, and Commerce, and which has existed more than a century, is not to suspend its labours and its sympathies because a province is annexed or a rivulet is passed. It is not for me to disparage the difficulties which you have to encounter. Those who pursue the paths of peace, and occupy themselves with the cultivation and development of the industry of man, no doubt have fallen—I will not say upon evil times—but doubtless on a period of great anxiety. But, gentlemen, remember this—the arts are eternal, and the nation that pursues and applies them with devotion and sincerity, in the intellectual power and in the elevating sentiments that their enterprise develops, finds the best security for the welfare of the people and for the duration of the state. It is with these feelings that I propose to you that we drink 'Prosperity to the Society for the Encouragement of Arts, Manufactures, and Commerce, and Success to the International Exhibition of 1862'.

The toast was drunk with protracted cheering.

Some Activities of Other Societies and Organizations

MEETINGS

FRI. 27 MAY. Visual Education, Council for, The Housing Centre, 13 Suffolk Street, S.W.1. 3 p.m. Sir Colin Anderson : *A brown study.*

WED. 1 JUNE. University of London, Senate House, Malet Street, W.C.1. 5.30 p.m. Sir John Gielgud, poetry reading : *Love and Death.*

THURS. 2 JUNE. Anthropological Institute, Royal, 21 Bedford Square, W.C.1. 5.30 p.m. Ernest Gellner : *Interpretation.*

Chemical Society, Burlington House, W.1. 7.30 p.m. Professor M. Heidelberger : *Chemical constitution and immunological specificity.*

Commonwealth Society, Royal, Northumberland Avenue, W.C.2. 1.15 p.m. Senator L. C. Daldry : *Nigeria's Federal Parliament.*

Royal Society, Burlington House, W.1. 4.30 p.m. H. Godwin : *Radiocarbon dating and quaternary history in Britain.*

THURS. 9 JUNE. Commonwealth Society, Royal, Northumberland Avenue, W.C.2. 1.15 p.m. Major Michael Crichton-Stuart : *National Trust for Scotland.*

THURS. 16TH JUNE. Commonwealth Society, Royal, Northumberland Avenue, W.C.2. At 1.15 p.m. Lord Layton : *The American attitude to European economic integration.*

Royal Society, Burlington House, W.1. 4.30 p.m. Sir John Eccles : *The nature of central inhibitory action.*

THURS. 23 JUNE. Commonwealth Society, Royal, Northumberland Avenue, W.C.2. 1.15 p.m. Mr. Richard Goold-Adams : *The Summit conference.*

THURS. 30 JUNE. Commonwealth Society, Royal, Northumberland Avenue, W.C.2. 1.15 p.m. Gunasena de Soyza : *Talk on Ceylon.*

OTHER ACTIVITIES

NOW UNTIL SUN. 26 JUNE. Arts Council, at Tate Gallery S.W.1. *Sickert centenary exhibition.*

MON. 30 MAY–SUN. 5 JUNE. Commonwealth Institute, Imperial Institute Road, S.W.7. Film show : *They came to stay—South Africa.*

NOW UNTIL SUN. 17 JULY. Victoria & Albert Museum, S. Kensington, S.W.7. Exhibition : *English chints.*